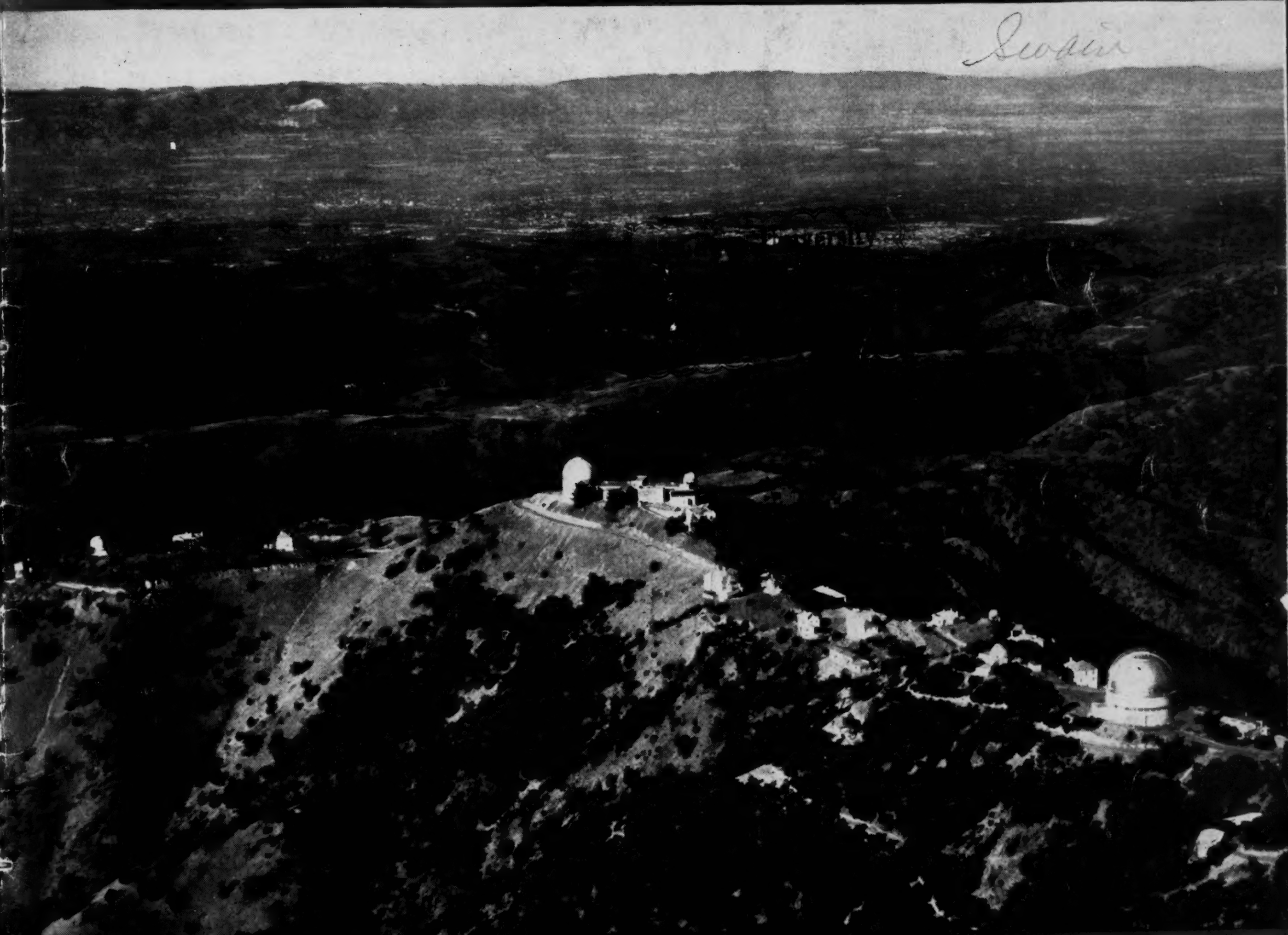
Sky and TELESCOPE



Swain

Lick Observatory

★

Vol. XX, No. 1

JULY, 1960

50 cents

★

In This Issue:

Swain

p

Sky and TELESCOPE

CHARLES A. FEDERER, JR., *Editor*
JOSEPH ASHBROOK, *Technical Editor*

Vol. XX, No. 1 JULY, 1960

CONTENTS

COVER: An aerial view of Lick Observatory of the University of California, on Mt. Hamilton, a 4,200-foot peak east of San Jose, the city in the valley in the picture's upper part. In the center is the observatory's main building, with the large dome of the 36-inch refractor at the left end and the 12-inch telescope at the other. Another early instrument is the 36-inch Crossley reflector, its dome seen about three-quarters of an inch from the left edge of the picture. The most recently built instruments are in the lower right, dominated by the dome of the 120-inch reflector. Two inches from the right edge is the 20-inch Carnegie astrograph, while the 22-inch Tauchmann reflector is on a small hill just halfway between the 20-inch and the 36-inch refractor. Lick Observatory photograph. (See page 4.)

SKY AND TELESCOPE is published monthly by Sky Publishing Corporation, Harvard College Observatory, Cambridge 38, Mass. Second-class postage paid at Boston, Mass.

Subscription: $5.00 per year in the United States and possessions; $9.00 for two years; $13.00 for three years. To Canada, Mexico, and all countries of the Pan American Postal Union, $6.00 for one year; $11.00 for two years; $16.00 for three years. To all other foreign countries, $7.00 for one year; $13.00 for two years; $19.00 for three years. Canadian and foreign remittances should be made in United States currency. Single copy 50 cents. Back numbers, as available, 50 cents each.

All notices of change of address must be sent one month in advance and accompanied by old and new addresses. When sending your renewal order, or writing in regard to your subscription, your current mailing address must be given. Return our bill form with renewal payment. Circulation manager, Nancy R. Bolton. Office staff: Virginia K. Cox, J. Caroline Nason, Mary Silva, John Simmons, Helen B. Sniegiecki, Stacia Strong.

Editorial and advertising offices: 49-50-51 Bay State Rd., Cambridge 38, Mass. Advertising rates are listed in STANDARD RATE AND DATA SERVICE, or sent upon request. Advertising manager, Henry M. Corrado. Editorial assistant: William E. Shawcross.

Unsolicited articles and pictures are welcome, bearing adequate return postage, but we cannot guarantee prompt editorial attention, nor are we responsible for the return of unsolicited material. The principal articles are indexed in THE READERS' GUIDE TO PERIODICAL LITERATURE.

Testing Gravity's Effect on Radiation

ONE basic assumption of general relativity theory is Einstein's principle of equivalence, which states that no detectable difference exists between gravity and the effect produced by acceleration of a body outside a gravitational field.

If this is true, light rays escaping from a star would lose some energy to its gravitational field, with a consequent lowering of the frequency of the radiation. Thus, all lines in the sun's spectrum should be slightly shifted to longer wave lengths, but this small effect has never been certainly observed. It would be much larger in the strong gravitational field at the surface of a white dwarf star, such as the companion of Sirius, but the observations are difficult and some astronomers regard them as inconclusive. Hence, there has been a long-felt need for a laboratory proof of the gravitational red shift.

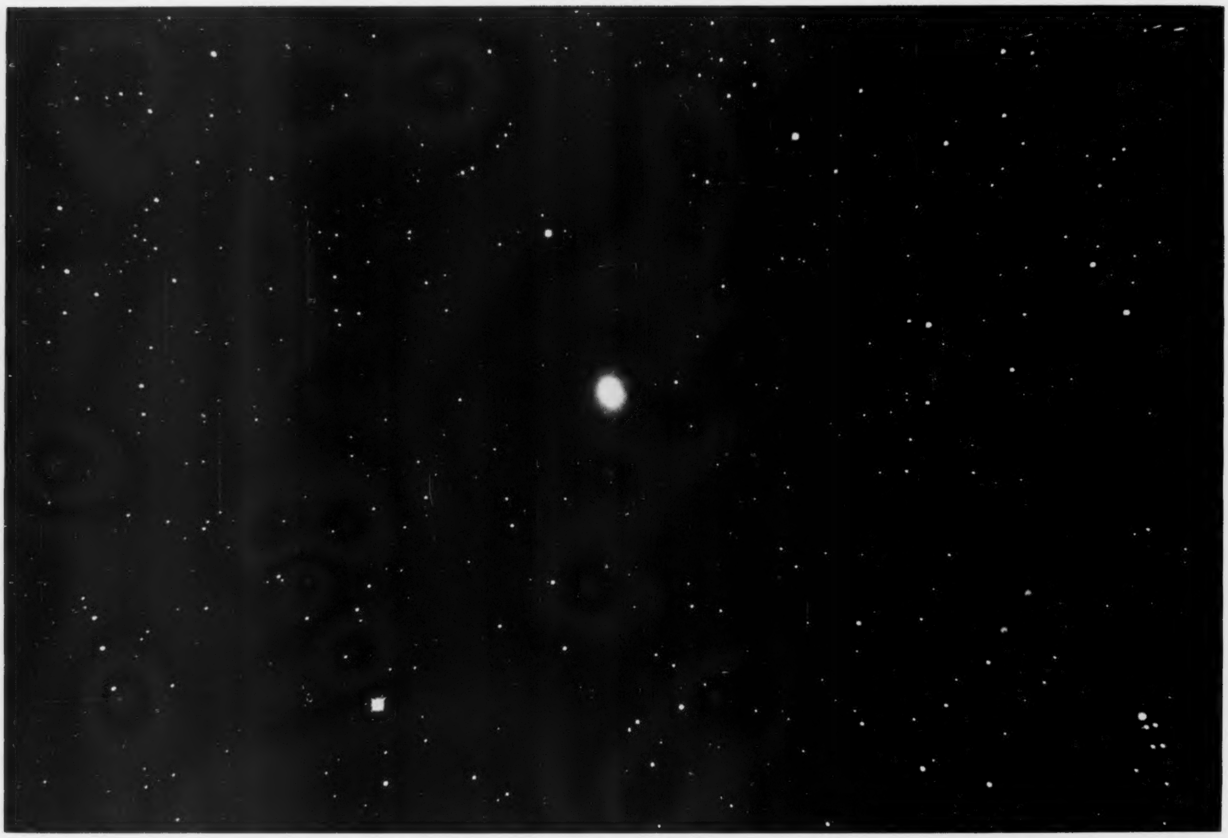
This has now been supplied at Harvard University by R. V. Pound and G. A. Rebka, Jr., and in England by less precise experiments at the British Atomic Energy Establishment. The test consisted of a demonstration that gamma rays moving upward against terrestrial gravity had decreased frequency, while gravity increased it for downward motion.

As certain radioactive nuclei decay, they emit gamma rays of a sharply defined frequency, and energy of this frequency can be absorbed by the element that is the end product of the decay. The Harvard physicists used radioactive cobalt-57 at one end of a 70-foot tower and its decay product, iron-57, at the other end.

To measure the frequency change, the cobalt source and iron target were given a slow relative motion, producing a Doppler shift in the frequency of the gamma rays. This motion was varied until peak absorption occurred, as indicated by a scintillation counter.

The expected alteration in frequency, as a result of the equivalence principle, was about two parts in 10^{15}. In the Harvard work, the measured change amounted to 105 per cent of the value predicted by Einstein, with an experimental uncertainty of 10 per cent.

This high accuracy could be obtained only by special precautions. The 70-foot tower in the Jefferson Physical Laboratory was filled with helium, at a closely controlled temperature. To obtain the maximum sharpness of nuclear resonance, the iron-57 and cobalt-57 samples were bound in metallic iron, thus eliminating recoil by the nuclei when they emitted or absorbed gamma rays. This precaution, upon which the success of the experiment depended, was based on the ideas of the German physicist L. R. Mössbauer (see *Science*, May 27, 1960, page 1588).



This is the first direct photograph taken when regular observations began with the 120-inch telescope, reproduced from a contact print of the original 5-by-7-inch plate. It shows the field of M32 (NGC 221), a companion galaxy to the famous Andromeda spiral, M31. N. U. Mayall began the seven-minute exposure at 5:08 Universal time November 28, 1959, when the seeing was mediocre. Eastman 103a-O emulsion was used, without a filter. The plate scale at the prime focus of the large reflecting telescope is 13.5 seconds of arc per millimeter. North is at the top, east at the right. All celestial photographs with this article are courtesy Lick Observatory, University of California.

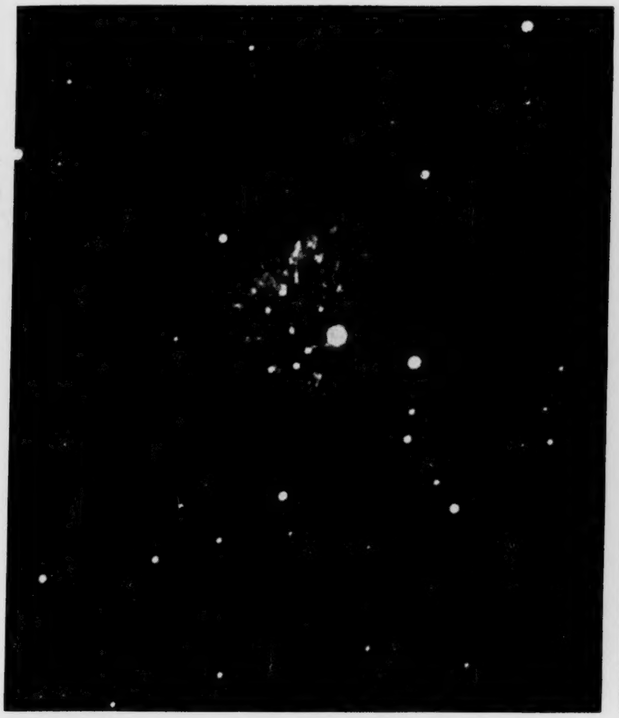
Lick 120-inch Photographs — I

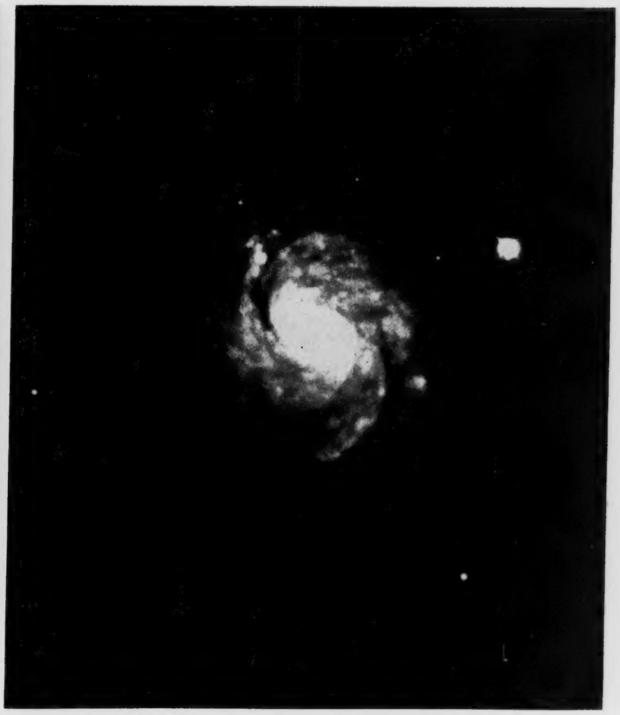
Morning sunlight gleams on the 120-inch reflector's dome, viewed from the road to Mt. Hamilton's Copernicus Peak, where a fire tower is located. A small part of the Santa Clara valley, immersed in fog, is at the far right.

EIGHTY YEARS AGO the first rock was blasted from the summit of Mt. Hamilton in California, as construction began on the observatory for which James Lick had donated $700,000. It was to have the world's most powerful telescope and to be as modern as possible in every respect.

Today, with its original 12-inch and 36-inch refractors, the famous 36-inch Crossley reflector, the 20-inch Carnegie astrographic camera, the 22-inch Tauchmann reflector, and its great 120-inch telescope, Lick Observatory is still one of the most up-to-date institutions in the world for optical observations of the heavens. The front-cover photograph shows its appearance from the air — a famous astronomical community overlooking the Santa Clara valley above San Jose. The adjoining picture shows the 120-inch dome, which is 96 feet in diameter, weighs 260 tons, and rises nearly

One of the early photographs with the giant reflector is of the spiral galaxy NGC 2403, located in the north circumpolar region of the sky, in Camelopardalis. Its 1960 position is right ascension $7^h\ 33^m.0$, declination $+65°\ 42'$, its photographic magnitude being 8.8. The exposure of 15 minutes was made by N. U. Mayall, beginning at 10:31 UT on November 29, 1959, with fair seeing conditions. A GG-13 filter was used with Eastman 103a-O emulsion. The reproduction enlargement is $3\frac{1}{4}$ times. North is to the left, east toward the bottom.





Three photographs taken with the new 120-inch telescope. At upper left, the expanding shell around Nova Persei 1901 is seen 58 years after its outburst, from a 30-minute exposure in red light (103a-E emulsion, RG-1 filter) at 5:33 UT on December 19, 1959, enlarged $7\frac{3}{4}$ times to 1.75 seconds of arc per millimeter. Above right is M77 (NGC 1068), a 9th-magnitude spiral in Cetus, enlarged $4\frac{3}{4}$ times from a 15-minute plate taken at 7:35 UT on November 29, 1959, 103a-O with GG-13 filter. Below is the striking galaxy NGC 2976, located near M81 in Ursa Major, a 20-minute exposure at 8:36 UT, December 29, 1959, on 103a-O without filter, enlarged nearly five times.

100 feet above the surrounding ground level.

Second in size only to the 200-inch telescope on Palomar Mountain, the 120-inch has already demonstrated its ability to probe the depths of space. During September and October of last year, observations with a Lallemand electronic camera at its coude focus showed that the nucleus of M31, our giant neighbor galaxy in Andromeda, is rotating at the very rapid rate of once around in 520,000 years (see page 8).

Direct photography with the 120-inch began late in November, some of the preliminary pictures obtained being reproduced on these pages. Although the atmospheric seeing was never really good during this "warm-up" period, the results indicate that the new instrument's great resolution and light-gathering power will be fully utilized over the years.

(To be continued)

FACING PICTURE: The Crab nebula, M1, in Taurus, originated from a supernova explosion in the year 1054 and is a strong cosmic radio source. This 30-minute exposure in red light (RG-1 filter on 103a-E emulsion) brings out the filamentary structure that is superimposed on the amorphous body of the nebula. N. U. Mayall took the picture beginning at 8:50:40 UT on November 30, 1959. This enlargement is 8.8 times the plate scale of 13.5 seconds per millimeter. North is at the left, east at the bottom.

NEWS NOTES

DIAMETER OF A RED GIANT STAR

When a star of appreciable angular diameter is occulted by the moon, it is possible to measure the time interval required for the moon's edge to cover the stellar disk, using a photoelectric cell and a high-speed recorder. For several years observations of this kind have been made at the Royal Cape Observatory in South Africa with its 24-inch refractor.

As a part of this program, an occultation of the 3rd-magnitude star Mu Geminorum was observed on February 21, 1956; the results have been reported by D. S. Evans in a recent issue of the *Monthly Notices* of the Astronomical Society of Southern Africa. The dimming of the star as it went behind the moon's limb was monitored by a photocell whose output was registered on a film moving 31 millimeters per second. The duration of fading, combined with the known travel rate of the moon, gave 0.023 second of arc for the angular diameter of the star – the size of a dime as seen from about 100 miles.

Since the distance of Mu Geminorum is about 160 light-years, its linear diameter is approximately 120 times the sun's, in good agreement with expectations for this red giant star of spectral type *M3* III. Dr. Evans points out, however, that the agreement may be accidental, as the star's distance is somewhat uncertain and the photometer tracing was not of the best quality.

TEST FOR WATER AREAS ON MARS

If there were an extended smooth water surface suitably located on the planet Mars, then a terrestrial observer would see a bright specular reflection of the sun, a possibility discussed by H. Dennis Taylor in 1895. The observable effect would be a short-lived flash, occurring when the earth and sun were on opposite sides of the zenith and equidistant from it, as seen from the hypothetical Martian water surface.

Writing in the 1959 fall issue of *Particle,* J. E. Westfall points out that four reports of flashes have been made in recent years by amateur observers of Mars: S. Mayeda (1937), T. Saheki (1951 and 1954), and C. McClelland (1954). In each case, however, the location of the flash on the disk of Mars disagreed with the condition mentioned above, so reflection from water was not the cause.

Mr. Westfall, who was an undergraduate at the University of California in Berkeley when he wrote, has investigated in detail the geometry of Martian specular reflections, as well as their predicted brightnesses. He emphasizes that flashes could occur only in the planet's tropical regions, in Martian latitudes less than about 24°. Under the most favorable conditions, the reflection from a lake one-tenth of a square mile in area should just be detectable in an 8-inch telescope.

The quarterly *Particle,* in which Mr. Westfall's article appeared, is devoted to original contributions by college and high school science students. It is available at $1.20 per year or 50 cents for a single copy from its publisher, Dunbar Aitkens, 2531 Ridge Rd., Berkeley 9, Calif.

SOLAR HEATING

Heating houses by sunlight is one of the major fields in solar-energy engineering. Early experiments at the Massachusetts Institute of Technology showed that solar houses could be built, but the cost was much too high for the system to compete with conventional heating methods.

A comprehensive study of this problem by Edward Speyer has now been printed as a 25-page article in *Solar Energy* for December, 1959. He concludes that there is no general area in the United States where solar house heating is economically feasible today. For it to become competitive, one of four things must happen: "(a) Severe rationing of coal, fuel oil, and gas. (b) The cost of fuel for house heating must go above approximately 50 cents a therm. (This is somewhat less than the cost of electric heat today; a therm is 100,000 British thermal units.) (c) An 80 per cent to 90 per cent reduction in the present cost of long-term energy storage of between 300 and 700 therms. (d) Development of methods of building and installing solar energy collectors of 50 per cent efficiency under average conditions for $1.50 per square foot.

"From an economic point of view, the most favorable regions for solar house heating, fuel costs being assumed equal, are mountainous regions and high plateaus (the Appalachian highlands and the Southwest plains). These regions have cold winter temperatures (large fuel bills to be saved) and large amounts of winter sunshine (relatively small collector area required). The least favorable regions are the Pacific Northwest, the Mississippi Valley, and the Gulf Coast."

ASTRONOMY COURSE FOR TEACHERS

A tuition-free astronomy course, designed especially for teachers and administrators in elementary and junior high schools, will be given this fall by the American Museum-Hayden Planetarium, with National Science Foundation help.

Beginning on September 28th, the class will meet for 15 consecutive weeks at 4:30 p.m. on Wednesdays. Registration is limited to 30 persons, and applications are being accepted in the order in which they are received. Forms are available from Dr. Franklyn M. Branley, American Museum-Hayden Planetarium, New York 24, N. Y.

IN THE CURRENT JOURNALS

THE EXPLORATION OF THE MOON, by Robert Jastrow, *Scientific American,* May, 1960. "One of the primary objectives of the first-hand exploration of the moon will be to obtain evidence on its temperature history. Such evidence will help to settle uncertainties about the origin of the sun and planets, and indicate whether the solar system is a common or a rare phenomenon in the universe."

THE ROTATION OF THE NUCLEUS OF M31, by A. Lallemand, M. Duchesne, and Merle F. Walker, *Publications* of the Astronomical Society of the Pacific, April, 1960. "It appears that the nucleus of M31 has about the same diameter as a giant globular cluster, but a mass about 100 times greater and a density and luminosity about 25 and 20 times greater, respectively. It is rotating in a period of 5.2×10^5 years, or about one to two orders of magnitude faster than the rest of M31. . . . The reason for the rapid rotation of the nucleus is not at all clear, but speculation on the cause of the phenomenon is probably premature."

CANADIAN ASTRONOMER DIES

Andrew McKellar, astronomer at the Dominion Astrophysical Observatory, Victoria, British Columbia, passed away on May 6th. He was internationally known for his observations of the spectra of comets and late-type stars.

Dr. McKellar, who was born on February 2, 1910, was educated at the University of British Columbia and at the University of California, where he received his doctorate in physics in 1933. From 1933 to 1935, he was a National Research fellow at Massachusetts Institute of Technology, and then he joined the Dominion Astrophysical staff. He will long be remembered for his applications of molecular spectroscopy to astrophysical problems.

INTERNATIONAL ACADEMY OF ASTRONAUTICS

To provide world technical leadership for the peaceful exploration of space, and to serve as a clearinghouse for astronautical information, the International Academy of Astronautics has been founded, with the aid of a $75,000 grant from the Guggenheim Foundation in New York.

The new group was organized by Theodore von Karman, California Institute of Technology, under the auspices of the International Astronautical Federation. Its membership will be limited to a small number of leaders in the fields of physical science, biology, and engineering. The initial members include Lyman Spitzer, Jr. (Princeton), J. A. Van Allen (State University of Iowa), and A. C. B. Lovell (Jodrell Bank).

Exploring the Solar System by Radar

Paul E. Green, Jr., and Gordon H. Pettengill, *Lincoln Laboratory,* Massachusetts Institute of Technology*

Ask the average person about exploration of the solar system, and he will probably give you an image of giant rockets firing complicated instruments into space. Or perhaps he will remind you of the richly detailed picture built up over the centuries from optical studies and added to during the last few years by infrared and radio observations. It may not occur to him, however, that radar techniques are beginning to play an important role, too.

Radar is, in a sense, simply two-way radio. Some sort of signal is emitted by a directive antenna on the earth, travels to the object being studied, is reflected in many directions, and a tiny remnant of it eventually arrives back at the earth to be collected by the same antenna. Since we know exactly what the transmitted signal is, we can compare the returned echo with what was transmitted, so as to test something about the target body, perhaps something that would be difficult to isolate and study in any other way.

One of the simplest examples of such a test is the measurement of distance. If the experimenter knows the speed at which energy travels, he can determine the target's distance just by measuring the elapsed time between transmission and reception — a much more direct and usually more accurate method than the optical use of trigonometric parallax. (Time measurements to one part in a billion are common with today's electronic equipment.) But, as we hope to show here, many more things than this have been done, and still more will assuredly be done in the next few years.

The first radars were not military devices at all, but instruments used to probe the structure of the ionosphere by vertical soundings. These date back to 1926, six years before K. G. Jansky made his first radio astronomy discoveries. In this article we shall omit the fascinating story of radar studies of the ionosphere, of meteor trails and aurorae, and concentrate on extraterrestrial objects, such as the moon, planets, sun, and the tenuous contents of interplanetary space.

Radar came dramatically to the attention of astronomers in 1946, when war-developed equipment proved capable of bouncing an echo off the moon, 240,000 miles away. For the next 12 years, the story of radar astronomy was that of moon echoes. Over that entire period, rapid improvements were being made in radar technology, yet these were still not sufficient to permit detection of the next most distant target, Venus.

Then, within a year of the March, 1959, announcement of successful contact with Venus, by a group under Robert Price at Lincoln Laboratory, there came the news that V. R. Eshleman's team at Stanford University had detected solar echoes (February, 1960). And there is talk that radar contact with Mars may be attempted during its opposition this coming December, or at the February, 1963, opposition. Why so much sudden activity after a 12-year interval when only the moon was observable?

The Effect of Distance

The reasons are clear when one appreciates the important role that distance plays in a radar detection. Venus at inferior conjunction is some 100 times more distant than the moon, whereas Mars at closest opposition is only $1\frac{1}{3}$ times as distant as Venus, and the sun $3\frac{1}{2}$ times. In a one-way transmission, the energy received is proportional to the inverse square of the distance; however, with radar the energy must not only reach the target but be propagated back again, suffering another inverse-square attenuation. The result is a received signal energy proportional to the inverse *fourth* power of distance. Venus has a diameter a little over $3\frac{1}{2}$ times that of the moon, and thus roughly 10 times the reflecting area. But its 100-fold greater distance means that the energy returned is $10/(100)^4$ or 10^{-7} that from the moon, if for both bodies the power reflected is proportional to area.

Making the same calculation for each of the planets, and plotting their detectability relative to the moon's, we get the pattern of points in Fig. 1. Several satellites and minor planets are also included. Clearly, after we have bridged the gap of 10^7 in detectability from the moon to Venus, there are many radar targets in close succession.

Another increase of 10^7 in radar performance beyond that needed to detect Venus would encompass all the planets except Pluto — provided detectability depended only upon the diameter of the body and its distance from Earth. Unfortunately, matters are not this simple. Discrepancies of several orders of magnitude from the numbers given in Fig. 1 are possible, due to different reflectivities

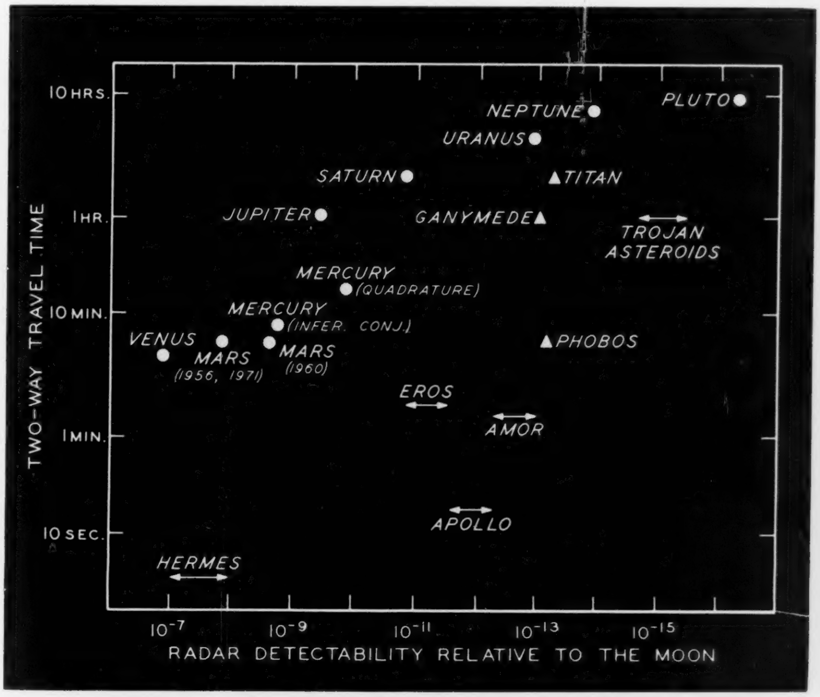


Fig. 1. For the planets, a few satellites, and some asteroids, the radar detectabilities are compared with that of the moon. These results have been deduced only from sizes and relative distances, without regard to possible differences in surface reflectivity. For the asteroids, approximations are given, since their sizes are uncertain. All illustrations with this article are from MIT's Lincoln Laboratory, unless otherwise credited.

*Operated with support from the U. S. Army, Navy, and Air Force.

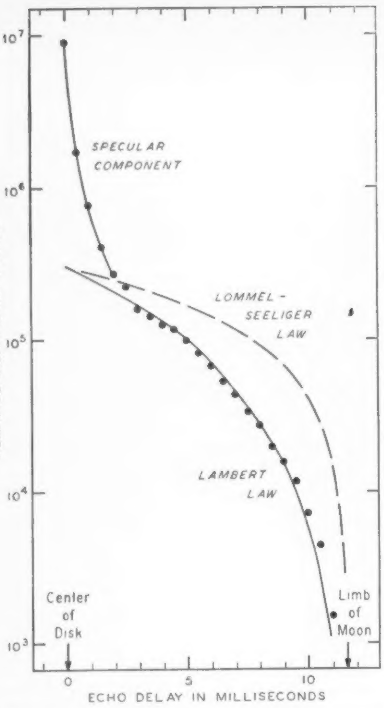


Fig. 2. Gordon H. Pettengill's observations of the radar brightness of the moon's disk at various distances from its center are shown by dots, each representing the sum of 24,000 pulses. At the frequency used, 440 megacycles per second, the outer portions of the moon scatter in accordance with Lambert's law, and not the Lommel-Seeliger law, which fits optical measurements better. Near its center, the lunar disk is much brighter by radar than Lambert's law predicts. At Stanford University, similar studies have been made.

of the planets' surfaces or the absorptivities of their surrounding atmospheres. As a matter of fact, the observed strength of the return signal can indicate the reflectivity of a planet, since the diameter and distance are already known.

Radar to the Moon

The first echoes whose characteristic delay time and Doppler frequency shift positively identified them as reflections from the moon were obtained by the U. S. Army Signal Corps in 1946. But it was puzzling that lunar echoes were not always observed even though conditions appeared to be favorable. Some hitherto unsuspected effect must have been taking place.

Australian and British scientists showed that the observed fading had two causes. A relatively rapid component stemmed from changing interference among simultaneous reflections from different regions of the lunar surface, as changing librations caused it to turn under the radar beam. And a propagation effect, Faraday rotation, was responsible for the slow fading which caused the signal to disappear for minutes at a time. This effect occurs when a wave passes through a region like the earth's ionosphere with a magnetic field present. Under certain conditions, the plane of polarization of the radar signal was being sufficiently twisted, as it passed twice through the ionosphere, that it arrived back at the receiving antenna in a cross-polarized orientation, producing zero output.

By unraveling the sources of the fading, it became possible to eliminate the ionospheric effects (through the use of circularly polarized transmissions, for instance), in order to study more directly the reflective properties of the lunar surface. In addition, the Faraday rotation could also be employed as a new tool to probe the properties of the terrestrial ionosphere.

An unexpected property of lunar reflections at radio wave lengths came to light with the discovery, by J. H. Trexler at the Naval Research Laboratory, that when a short pulse was sent out, most of the returned signal power was confined to an interval of a few hundred microseconds. So brief an echo could only have been produced by a lunar terrain having relatively gentle slopes, as contrasted to the precipitous and craggy surface shown in popular illustrations. Further verification was soon provided by accurate measurements of the travel time, proving that the sharp echo originated in the nearest region of the moon.

It had long been known that at optical wave lengths the disk of the full moon exhibits a striking uniformity in apparent brightness from center to edge. The radar work made it clear that the nature of scattering from the moon's surface was distinctly different when measured with wave lengths of tens of centimeters instead of tenths of microns. Unlike its visual appearance, the moon at radar wave lengths has a strong highlight in the center.

As radar transmitters became more powerful and antennas larger, the echoes received back from the moon stood higher and higher above the receiver noise level. Within the past few years, sufficient signal has become available at several stations to show that there is in fact observable echo power all the way out to the lunar limb. Fig. 2 shows the results of one such recent measurement. In addition to the highlight or specular component, there is a diffuse contribution which very nearly obeys a Lambert scattering law. A reasonable fraction of the moon's surface, therefore, must have irregularities that are comparable in size to radar wave lengths – a conclusion of some importance to those who may wish to land there.

How can we learn where these rough portions are? Photographs, of course, tell quite a bit about the topography, and measurements of the lengths of shadows cast by objects on the moon's surface have given us much information about the height scale of its gross features. The distribution of radio energy reflected from various parts of the disk would help fill remaining gaps in our understanding. If we had sufficiently narrow beam-widths, a radar "picture" of the moon could be taken by simply scanning across its disk. However, another approach that does not require resolution in angle has recently shown promise.

Mapping the Moon by Radar

Suppose a pulse of radar energy reflected from the moon is observed. The echo will have a longer duration than the original pulse, because the reflection from the edge of the moon reaches us later than that from the center of the disk. Hence, by selecting a part of the returning signal

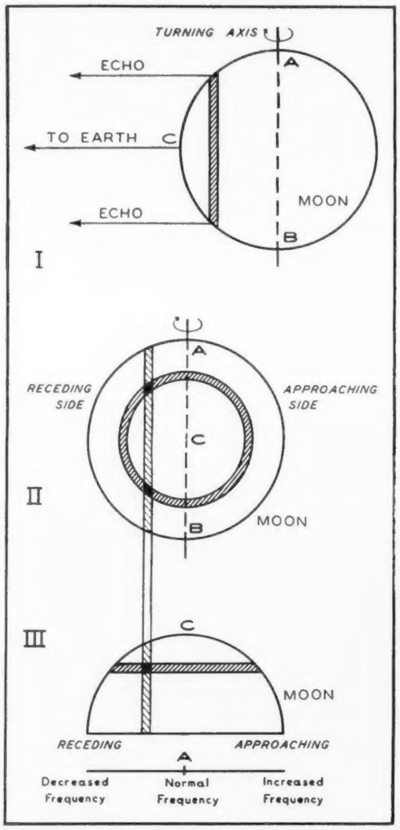


Fig. 3. Mapping the moon by radar. In diagram I, by selecting that part of the echo within a limited interval in range, we observe only the shaded area, a ring on the moon as seen from the earth in II. C is the center of the disk, and AB is the axis around which the moon appears to turn, because of changing libration. Here AB has been arbitrarily drawn perpendicular to the line of sight. Half of the turning disk is approaching, half receding. By further selecting a limited frequency interval, we observe only the narrow strip of disk between the vertical lines. In III, looking down on the moon, we see one of two small areas thus isolated by the combined selection of range and frequency. Compare III with the observational record in Fig. 4.

within a limited time interval, we know that we are observing a ring-shaped portion of the disk, centered on its midpoint. But how do we isolate the energy reflected from a particular part of this ring?

To achieve this, advantage is taken of the changing libration of the moon, which causes a slow apparent turning of the moon as seen by a terrestrial observer. At any moment, half of the moon's face is approaching us and half receding, with respect to the center of the disk. Thus the frequency of the energy returned from the ring differs from point to point, in a predictable way, because of the Doppler effect. Fig. 3 shows the relation between range and frequency for a turning spherical body such as the moon.

If we could arrange to measure simultaneously both range and frequency with sufficient precision, some semblance of a map could be prepared. The separation of returns from different parts of the lunar surface is possible because the energy received at a given range and given frequency must have been reflected only from two definite points on the moon. Techniques which have been available for years give adequate accuracy in range. The frequency measurement, on the other hand, calls for a new level of stability, several parts in 10^{11} over the observing interval of 2.5 seconds, if useful resolution is to be achieved.

This stability has recently been obtained, and Fig. 4 shows some experimental results gathered by this technique. It is hoped that a number of these measurements will make it possible to match the observed spectra with specific parts of the lunar disk, and build up a picture of the moon in terms of radar reflectivity.

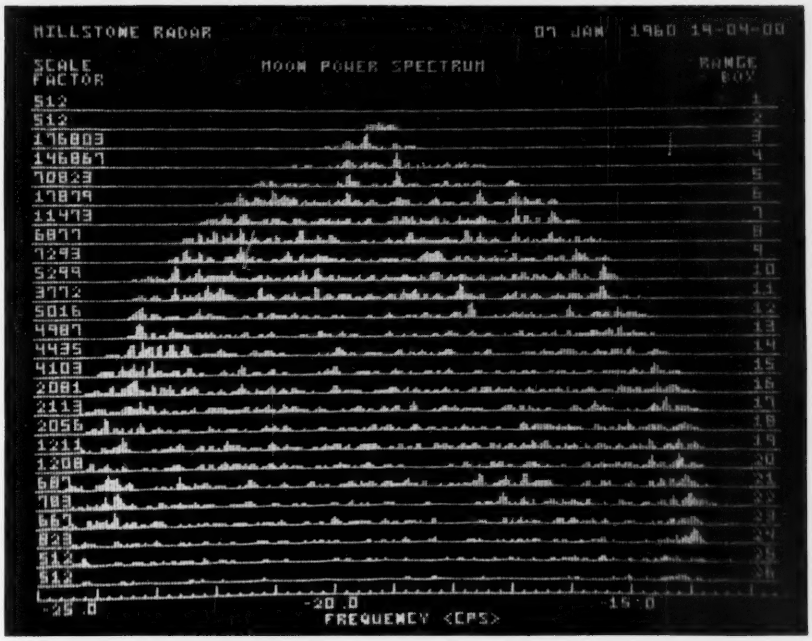


Fig. 4. This preliminary radar map of the moon is from 440-megacycle observations with the 84-foot Millstone Hill antenna on January 8, 1960, at 0:04 Universal time. The sharp semicircular boundary corresponds to the moon's edge seen from above (as in III of Fig. 3), the part of the moon nearest the earth being at the top of the map. The range increases downward by steps of 0.0005 second of radar echo time per line. Since the echoes from the center of the moon as we see it are enormously stronger than the limb echoes (bottom), the signal strengths have been scaled down by the factors labeled at the left.

The span of frequencies covered by the echo is determined by the product of the target's radius and turning rate. Also, the total time duration of the echo is a direct measure of the radius. Hence, the rotational rate of a planet may be found by radar. Such a study of Venus would be very important, since the length of that planet's day is still unknown. Perhaps the most interesting property of these methods is that angular resolution is not required. As radar capability improves, Venus and Mars may be studied in detail with good surface resolution, without recourse to impossibly small antenna beam-widths.

Fig. 5. A part of Stanford University's antenna used for the first successful radar observations of the sun. It is designed especially for operation at the low frequencies required for obtaining echoes from the solar corona. Eight side-by-side rhombic antennas make up the array, one and part of a second being seen here. Stanford University photograph.

Future Techniques and Equipment

The application of these methods to very distant targets will require continuing efforts in four major areas: transmitters, antennas, low-noise receivers, and signal-processing techniques. The average power available at frequencies extending from 30 megacycles per second to 30,000 megacycles must be increased. In many cases, the radio power available at present is already crowding the capacity of a single transmission line. New methods are needed to generate and distribute the power over the antenna surface without having to funnel it all through one transmission line. In order to preserve complete knowledge of the transmitted wave form, these new transmitters must not distort the output, even at the highest

Fig. 6. An artist's conception of the 600-foot antenna under construction for the U. S. Navy at Sugar Grove, West Virginia. This huge steerable paraboloid will be precise enough to work at wave lengths as short as the neutral hydrogen line at 21 centimeters. It will be an important tool for future planetary radar experiments. The installation, known as the Naval Radio Research Station, is to cost about $80,000,000. U. S. Navy photograph.

frequencies and powers that may be used.

Perhaps the most important field for improvement is antenna capability. In radar systems, the antenna plays a dual role, contributing to the outgoing "power-on-target," and also determining the amount of scattered signal that may be gathered into the receiver. At the present time, antenna designs so nearly achieve full theoretical efficiency, for a given size and operating frequency, that little remains but to increase the collecting area if more sensitivity is to be realized. Certainly the current trend lies in that direction. An example of the approach that has been used at relatively low frequencies (30-60 megacycles) is the Stanford solar radar installation, shown in Fig. 5.

For the major part of the spectrum available to radar astronomy (substantially the same region of interest in radio astronomy), however, the choice seems to favor a parabolic reflector illuminated by a relatively simple antenna located at its focus. An instance of a very large paraboloid under construction is seen in Fig. 6.

To a certain extent, the value of an antenna of given size may be improved by operation at a higher frequency (shorter wave length). As the wave length is shortened, the reflecting paraboloid forms a narrower beam, concentrating more of the transmitted energy on the target. But the dimensional accuracy of the antenna and its mount must be proportionately greater. Furthermore, above 10,000 megacycles absorption in the earth's lower atmosphere becomes important. And in some cases, as the sun, the reflection properties of the target tend to place an upper limit on useful frequencies.

Although much work may be carried on with the simple displays that conventional radars use — such as oscilloscopes and cameras — a digital computer of some sort is required for more advanced signal processing. When the signal-to-noise ratio of the desired return falls below unity, special processing is necessary to extend the detection sensitivity. But even where sufficient signal is available, computers are needed if techniques such as those described for lunar mapping are to be attempted.

Finally, a continued effort is required to reduce receiver noise temperatures, a problem discussed by F. D. Drake in SKY AND TELESCOPE for December, 1959, page 87. Masers and variable-reactance amplifiers appear promising, and in the future may be improved so much that the residual noise level will be limited only by the background temperature of the sky or, sometimes, the target. This theoretical limit is already near at hand in some cases, although the availability of reliable amplifiers using these principles at all interesting frequencies is still limited.

THE VENUS EXPERIMENTS

Initial astronomical use of such a device came in February, 1958, when Lincoln Laboratory employed a 440-megacycle solid-state maser (Fig. 7) in its first Venus observations, described on page 384 of the May, 1959, issue. When the experiment was repeated, at the next inferior conjunction in September, 1959, a parametric amplifier was used. In both

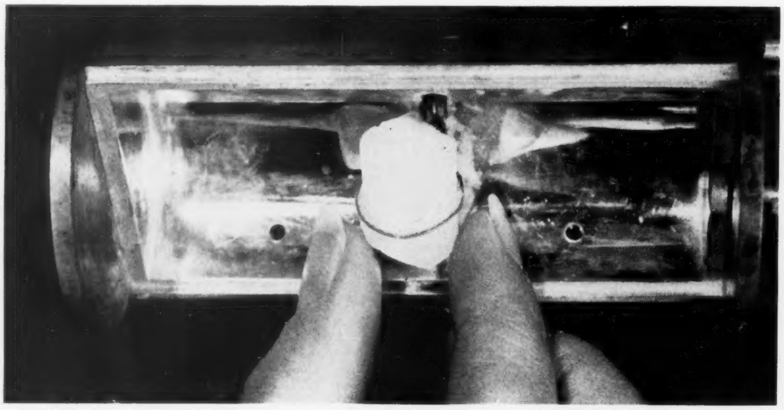


Fig. 7. This small crystal forms the heart of the maser built by Robert H. Kingston for amplifying radar echoes from Venus. The paramagnetic crystal accepts power delivered at 5,400 megacycles through the entry at the right, and uses it to augment the weak 440-megacycle signal that flows in the loop of wire around the crystal.

cases the background noise at the receiver input was kept down to 170° Kelvin.

The 440-megacycle transmitter sent a sequence of several thousand pulses, each 0.002 second long and several hundred kilowatts in peak power, into the 84-foot Millstone Hill antenna dish, which was pointed at Venus. The pulse sequence lasted for the entire five-minute round-trip travel time, so the last pulse was transmitted just before the echo of the first was due. Then the antenna output was switched over to feed the low-noise receiver, whose output was recorded on tape and later processed in a digital computer. Each such 10-minute operation constituted a "run."

The processing had two purposes. First, the individual echoes were much too weak to be distinguished from the background noise, so it was necessary to add together all of the several thousand received echoes-plus-noise to build up the signal-to-noise ratio. Since the echoes have a more or less fixed structure, and the noise is different from pulse to pulse, the former add up faster than the noise.

A second function of the signal-processing equipment was to determine the correct value of the planet's distance. The transmitted sequence of pulses was deliberately made nonperiodic, since otherwise it would be impossible to tell which received pulse corresponded to a particular transmitted one. By matching up the outgoing and returning patterns, no ambiguities in time of travel will remain. This matching is too lengthy a job for the computer to do while the observations are in progress, so in the 1958 experiment the received signals were recorded for later treatment. In the second Venus experiment, a digital computer (Fig. 8) located at the radar site was programmed to do part of the processing during each actual run.

At the 1959 Venus conjunction, an experiment similar to this was carried out by J. V. Evans at Jodrell Bank in England. Our laboratory's 1958 work had produced four valid runs, of which two contained large-output signals agreeing in range. Since it was thought that the 25-million-mile distance to Venus had been measured to better than 250 miles, this implied that the solar parallax had been redetermined to within one part in 100,000. Over 150 runs were made during the 1959 Lincoln Laboratory effort, yet no echoes as strong as those of 1958 were observed, either in England or America, though the former group did get weak indications for a distance consistent with the solar parallax determined in the 1958 experiment.

It is difficult to explain the disparity between the results obtained at the two Venus conjunctions. Our current feeling is that the planet's reflectivity may be highly variable with time, and that the two successes in 1958 were observations made on very favorable occasions.

Fig. 8. The CG-24 computer seen here works directly from the output of the Millstone Hill radar in tracking artificial satellites, and to sum up Venus echoes. It was used to make the lunar map in Fig. 4.

Solar System Distances

Astronomers, in specifying the mean distance of the earth from the sun, ordinarily speak of the corresponding solar parallax – the angular radius of the earth as seen from the center of the sun. Several proposed values of the solar parallax, with their probable errors, are compared in Fig. 9. H. Spencer Jones' 1931 result is from triangulation of Eros in that year; E. Rabe's 1950 determination is from perturbations of Eros, while the 1889-1924 figure is the average of seven optical methods. The value 8.800 seconds of arc is not an observed but an adopted one, used in ephemerides. With these is compared the 1958 radar evaluation. The distressing thing about this compilation is the wide variance among the proposed numbers, with even the regions of probable error failing to overlap. It is hoped that additional radar observations will clear up the discordance.

But there is more to the story of interplanetary radar distance measurements than refining the value of the solar parallax. The method should ultimately allow the determination of the orbits of some planets to within a few miles. When this accuracy is attained, gravitational perturbations of higher order will have to be considered in interpreting what is observed. It should also be possible to study the relativistic motions of the perihelia of several other planets besides Mercury. Mars is especially attractive since it comes fairly near to us, has a rather eccentric orbit, and has an atmosphere whose retarding effect on the radar signal is probably negligible.

The effect of the intervening medium on the signal's speed of travel is important. By far the largest effect is caused by the dielectric constant differing slightly from unity, due to free electrons in interplanetary space and in the ionospheres of the earth and the target planet. This retardation is greater at lower frequencies. For the 440-megacycle frequency used in the Venus experiment, it was calculated that a distance error of less than one part in a million would result from the combined effects of our ionosphere and an average of 1,000 electrons per cubic centimeter throughout the intervening space. Had the measurement been made at 50 megacycles, the corresponding discrepancy would have been one part in 60,000.

We can put this difference to work in

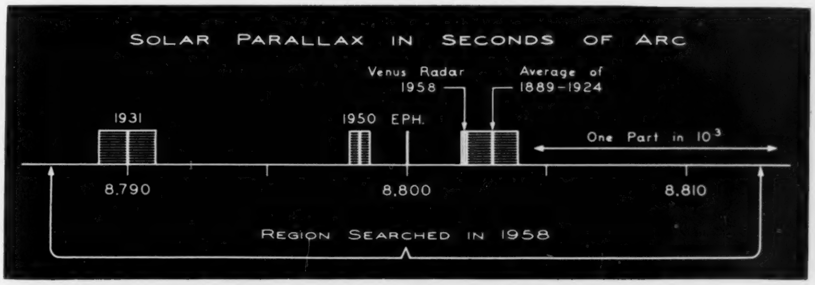


Fig. 9. Solar parallax is often used to specify the mean distance from the earth to the sun. Lincoln Laboratory's value from Venus radar experiments in 1958 is here compared with others, the probable errors being indicated by the shadings: 1931 Eros, 0.001 second of arc; 1950 Eros, 0.0004; 1958 Venus, 0.0001; and 1889-1924 (seven determinations), 0.001 second.

studying the electron content of space and in the neighborhood of the target. If a pair of radars operating at widely separated frequencies, such as 50 and 400 megacycles, can measure the travel time to distant bodies to one part in 60,000, and if the effect of the earth's ionosphere can be subtracted out, then the density of free electrons in interplanetary space could be deduced from the excess time-of-flight observed with the low-frequency radar over that of the high-frequency one. (Of course, this experiment would tell us only the total number of electrons between us and the planet, and in the absence of other data we could not say what fraction was in space and what fraction was in the vicinity of the planet.) Finally, knowing the total electron content, we could improve the original range measurement.

Radar and the Sun

The procedure that was used to detect echoes from the sun's ionized corona is much like that employed for Venus, with two important differences. First, the sun itself generates so much radio noise that there is no particular point in working hard to minimize receiver noise. Second, the operation is at much lower frequencies, 20 to 50 megacycles being required. If higher frequencies are used, the signal penetrates so far into the corona before reflection that absorption losses become severe. At still lower frequencies, the signal is apt to be blocked by our own ionosphere.

In April, 1959, the first successful solar radar experiment was carried out by researchers at Stanford University (see page 281 of the March issue). The strength of the echoes turned out to be in very close agreement with theoretical predictions published by the Australian radio astronomer F. J. Kerr in 1952. One important difference was that the returns appeared to come more or less uniformly from a wide range of depths in the corona. This might be expected if the coronal region had large irregularities.

The Stanford experiment used a high-power communications transmitter operating at 26 megacycles, feeding the array of eight rhombic antennas already partly shown in Fig. 5. The transmission consisted of a series of alternate 15-second on-and-off periods lasting for 15 minutes, approximately the time of flight to the sun and back. Again, a digital computer processed the received signal, so that the combined energy of all the individual returns could be used to enhance the final signal-to-noise ratio.

With the rapid progress of radar techniques, we may look forward to even more revealing radar studies of the sun over the next few years. Range-frequency maps of the corona, analogous to those already made for the moon, might unlock many secrets about the dynamics of the sun's outer envelope.

Even though some important things have been done, the history of radar astronomy has barely begun to unfold. As usual when a new tool becomes available, the most interesting results will be the ones we cannot foresee.

Some Spectra of Nova Herculis 1960

THE Norwegian Academy of Sciences on May 3rd gave its Fridtjof Nansen award of about $350 to the Oslo amateur astronomer Olaf Hassel, who discovered a 5th-magnitude nova in Hercules on March 7th (see page 414 of the May issue). He detected the object with binoculars that morning about 5:30 a.m. Central European time, in twilight so bright that a few minutes later the star was unrecognizable.

Mr. Hassel is already known to astronomers for his discoveries of comets. He independently found Comet 1939d.

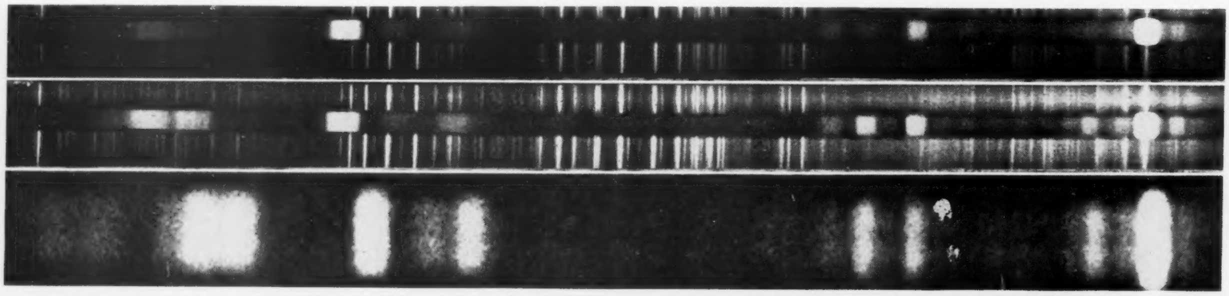
Spectroscopic observations of Nova Herculis by Dean B. McLaughlin, University of Michigan, have revealed an unusual feature — the red emission line at 6374 angstroms wave length, characteristic of the solar corona. It is due to iron atoms that have lost nine electrons, and can arise only at extremely high temperature and low pressure.

Coronal lines were first detected in an extrasolar source when W. S. Adams and A. H. Joy found both the red and green lines in the spectrum of the recurrent nova RS Ophiuchi in 1933. Evidently they are common in recurrent novae, having been recognized in T Pyxidis (1945) and T Coronae Borealis (1946), and were again present in RS Ophiuchi in 1958.

Four typical novae hitherto have shown the red coronal line: Nova Aquilae 1918, CP Lacertae (1936), CP Puppis (1942), and CT Serpentis (1948). Dr. McLaughlin notes that this line appears and strengthens during the declining stages of a nova, along with the forbidden lines of doubly ionized oxygen. Care is needed in establishing the presence of the red coronal line, which is partially superimposed on the 6364-angstrom forbidden line of neutral oxygen, the weaker companion of a pair whose other member is at 6300. Hitherto, the most striking occurrence was in CP Puppis, where the coronal line was considerably stronger than 6364 and nearly matched 6300.

According to Dr. McLaughlin's observations, the first trace of the red coronal line in Nova Herculis 1960 appeared in mid-March. By April 22nd, it was twice as strong as 6300, and by May 19th was estimated to exceed 6300 by a factor of five. This is the strongest known occurrence of the red coronal line in a typical nova.

The University of Michigan astronomer has supplied the spectra of Nova Herculis reproduced here, the upper two taken with a two-prism spectrograph on the 37-inch reflector at Ann Arbor, iron-spark comparison spectra (bright lines) appearing above and below the nova. No comparison spectrum was exposed for the third case, when a quartz spectrograph was used on the same telescope.



Dean B. McLaughlin took these spectra of Hassel's nova on (top to bottom) March 23rd, April 22nd, and May 19th. The upper two are enlarged 14½ times, the lower one 45 times to a slightly smaller wave-length scale. The intense emission line at the extreme right is hydrogen alpha, at 6563 angstroms. To the left of it is the 6374 red coronal line that was very strong in May, and to its left the much fainter 6300 line of neutral oxygen. The hydrogen-beta line at 4861 angstroms is about two inches from the left edge; to its right are two lines of triply ionized oxygen. Other lines are at 4640 angstroms (N III), 4686 (He II), 5755 (forbidden N II), and 5876 (He I). University of Michigan photograph.

At the left, seen near Frank Grow's 8-inch telescope, are a few of the nearly 3,000 persons who attended the Los Angeles Astronomical Society's star party last March. Photograph by Ed Edwards. At the right, in a picture by the author, Clarke Harris demonstrates a mirror-grinding machine. The society's 16-inch mirror blank is to his left.

Some Suggestions for a Public Star Party

LEIF J. ROBINSON, *Los Angeles Astronomical Society*

A STAR PARTY provides an excellent opportunity for an amateur club to serve its community, particularly with rising public interest in space exploration and, consequently, the heavens. The recent experience of the Los Angeles Astronomical Society may be of value to other groups considering similar events.

Our efforts began last February at an executive board meeting, when Jim Benson suggested that the society hold a public star party during the March eclipse of the moon. He had already contacted the California Museum of Science and Industry, 700 State Dr., Los Angeles, which had expressed interest and offered to assist in any way possible.

Assured of a sponsor with excellent physical facilities, our board approved the suggestion and put Mr. Benson in charge. Five committees were then set up: publicity, physical arrangements and display, speakers, publications, and legal. They planned the printing of information leaflets, parking facilities for members and guests, and the arrangement of displays. Press releases were prepared, being distributed by the museum to all high schools and junior high schools, newspapers, radio and television stations in the Los Angeles area.

A star party cannot succeed without telescopes, nor without the club members to man them. The great interest within the society resulted in more than 40 telescopes of many varieties ready for the event, the largest being Frank Grow's 16-inch portable reflector.

Two days before March 13th, a final board meeting was held to confirm all arrangements. At this time the necessary responsibility releases, insurance policies, and other required papers were signed.

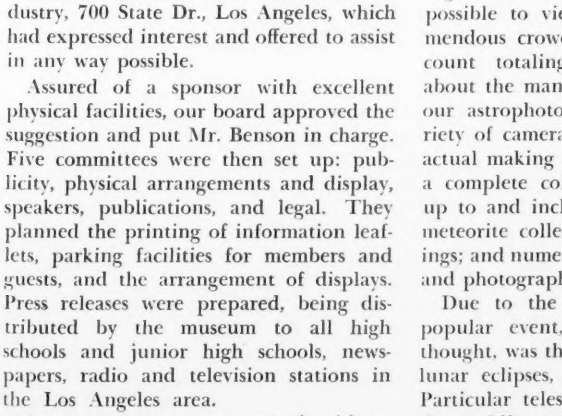
As so often happens with well-intended observing plans, the sky on eclipse night was cloud-covered, making it impossible to view the moon. But a tremendous crowd showed up anyway, our count totaling 2,936! They swarmed about the many displays, which included our astrophotography section's large variety of cameras; a demonstration of the actual making of a mirror, together with a complete collection of mirror blanks, up to and including a 16-inch; a micrometeorite collecting cone; telescope castings; and numerous astronomical drawings and photographs.

Due to the poor weather, the most popular event, and an excellent forethought, was the showing of slides of past lunar eclipses, accompanied by lectures. Particular telescopes of great interest to the public were: Mr. Grow's 16-inch; a 6-inch Maksutov by Gordon Konstanzer (see June issue, page 502); a 12½-inch reflector made by Clarke Harris; and a 6-inch "plumber's nightmare," thrown together by our society president, Thomas Cragg.

The 16-inch telescope remained on display in the museum foyer after the star party, along with information concerning the society. As a result of the affair, many communications were received by our secretary, and at our next regular meeting there were about 40 new and prospective members!

From our experience, a successful star party requires a general chairman with ambition and foresight, a sponsor to assist in the physical arrangements and publicity, strong participation by the society's members, and an adequate publicity campaign.

Any further information will be gladly provided by our secretary, Miss L. Carlson, Los Angeles Astronomical Society, 3047 Vista St., Long Beach, Calif.



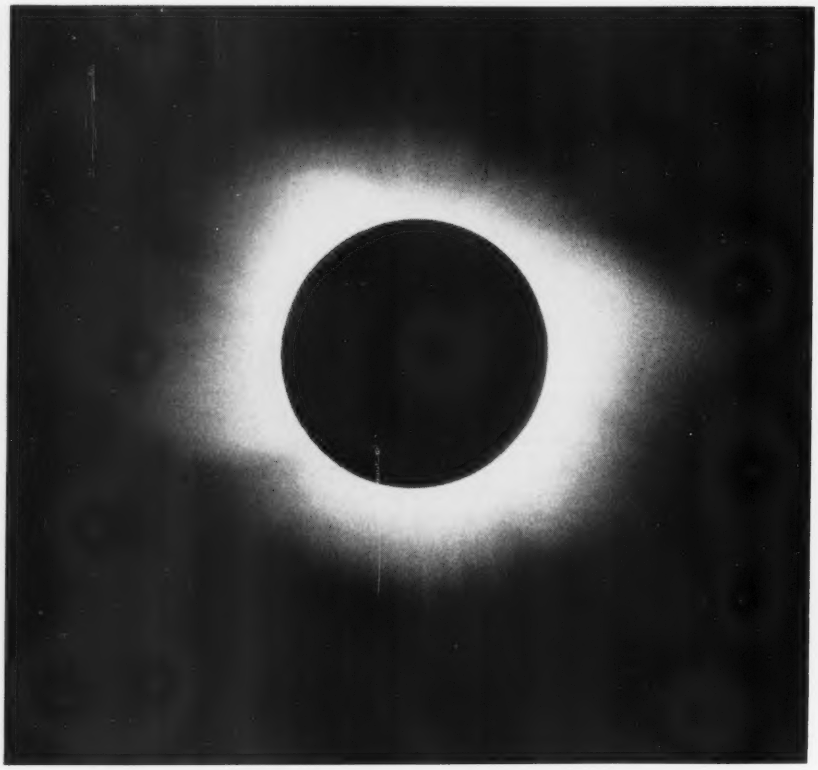
Among the many displays set up by LAAS members was one of homemade eyepieces and prism accessories by Charles Chinzi. In lower center the components of a Ramsden are shown. Photograph by L. J. Robinson.

GRIFFITH 25TH ANNIVERSARY

May 14, 1960, was the 25th anniversary of the opening of Griffith Observatory and Planetarium, at Los Angeles, California. During this quarter century, about 4,250,000 persons have attended some 17,500 planetarium demonstrations, and more than two million have looked through the Griffith 12-inch refractor.

Operated by the city of Los Angeles, the institution has been directed by C. H. Cleminshaw since 1958. He succeeded Dinsmore Alter, the first director, who is well known as an expert in studies of the moon.

NEXT WINTER:



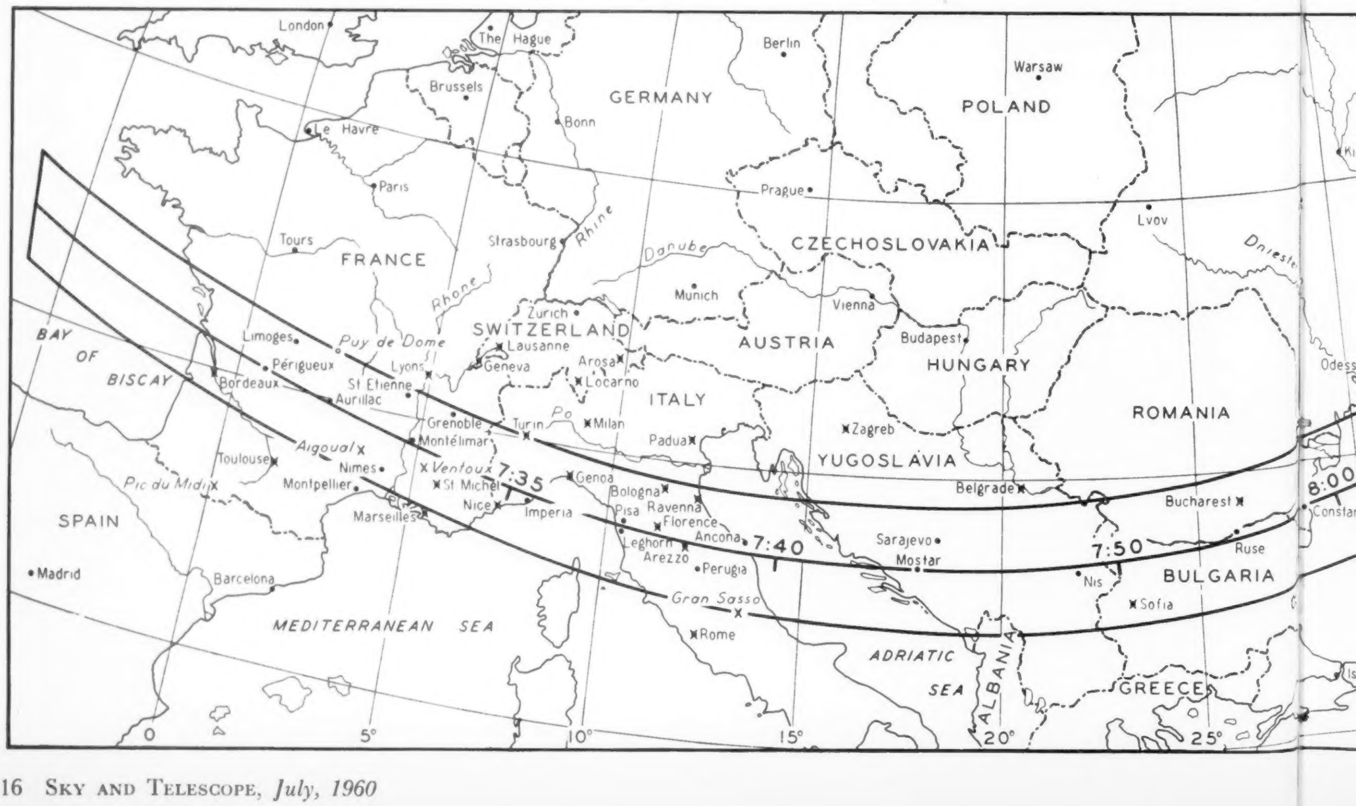
On a hill near the center of Las Palmas, Grand Canary island, at the instant of totality during the solar eclipse of October 2, 1959, a patch of clear sky allowed the author to photograph the solar corona, a fantastic halo of pearly white light that fades gradually into the darkness of the sky. Its general shape on that date, with streamers appearing in all directions but more extended at the sun's equator, seemed in accordance with a lessening of solar activity. A 50-millimeter f/12 camera was used for this one-second exposure through a yellow filter. North is toward the upper right. Other photographs of this eclipse were published in this magazine in November and December, 1959, and February, 1960.

TWO recent total eclipses of the sun, in October, 1958, and October, 1959, were witnessed by relatively few people, because the paths of the moon's shadow lay mainly over oceans or deserts. But on February 15th next year, the sun will be fully obscured for millions of persons in southern and eastern Europe.

The track of totality begins in the Bay of Biscay, passes through southern France and across Italy, the Balkan countries, and the Black Sea, then crosses a vast stretch of southern and eastern Russia, to finish in northern Siberia. The event will be visible as a partial eclipse over an area extending from near Spitsbergen to Arabia, and from West Africa to Manchuria. Nothing of the phenomenon is observable from North America.

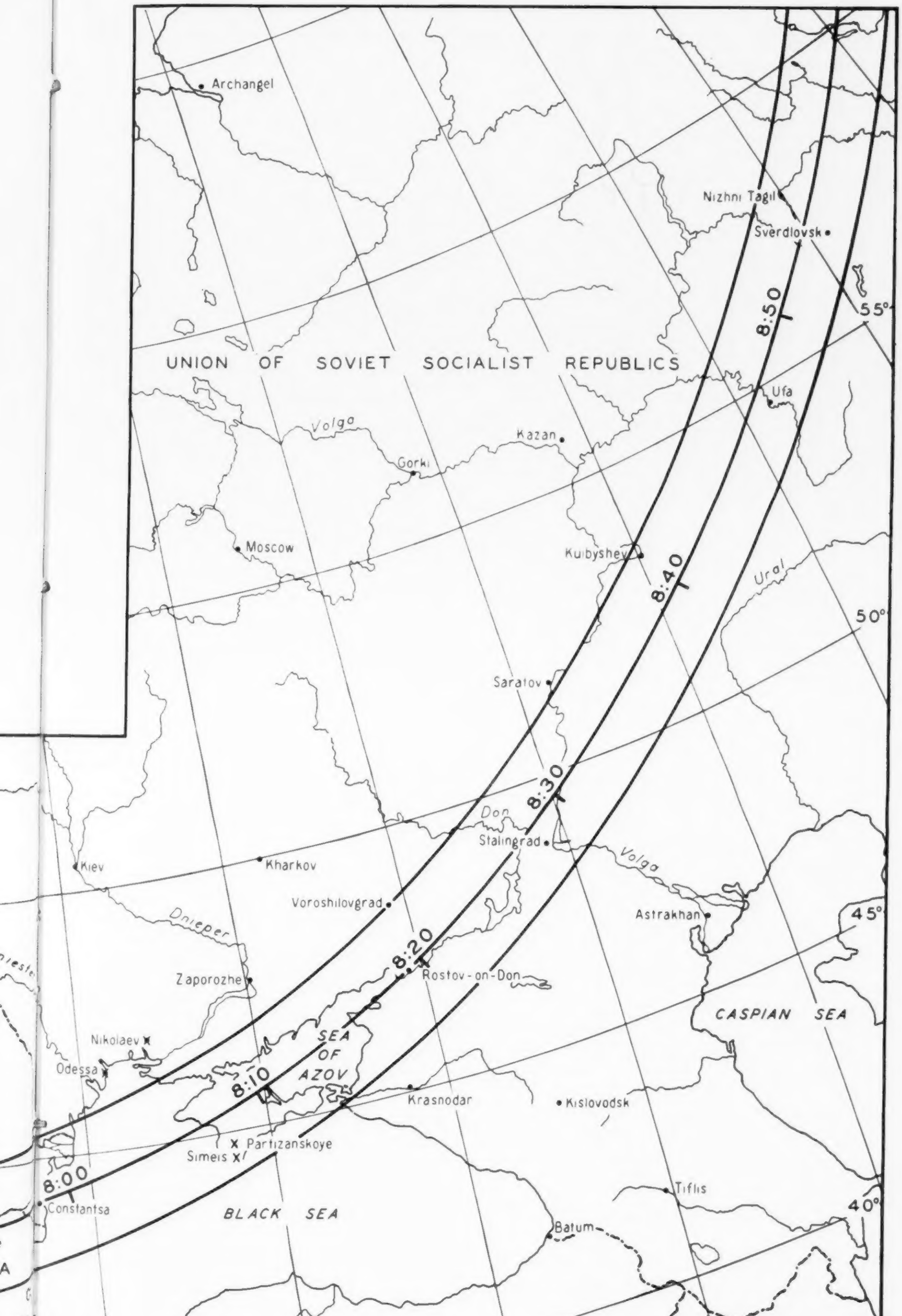
In the map of southern Europe, the track of totality is shown, except for its eastern parts. The path is 130 miles wide at its beginning, at sunrise in the Bay of Biscay, and 164 miles at its middle. The duration of totality will be one minute 39 seconds at sunrise, and two minutes 45 seconds where totality occurs at local noon, in southern Russia.

The totally eclipsed sun will be very near the horizon in western France, reaching an altitude of about 10 degrees in the



ER: A TOTAL SOLAR ECLIPSE

M. de Saussure, *University of Geneva, Switzerland*



eastern part of that country, and between 12 and 15 degrees for the Italian peninsula. The height of the sun will be greatest, about 27½ degrees, at Rostov-on-Don in the U. S. S. R.

Since the eclipse passes through densely populated regions, many cities and no fewer than a dozen observatories will see totality. In the map, cities having an observatory are indicated by crossed dots, isolated observatories by crosses, if these stations lie within 100 miles of the limits of the eclipse track.

The towns of Périgueux, Aurillac, and Montélimar in the south of France lie on or very near the central line. Larger cities seeing totality include Bordeaux, with its university observatory, Limoges, St. Etienne, Grenoble, and Nimes. In the French Riviera, there is Nice with its observatory on Mont Gros. Further stations are Mont Aigoual (5,140 feet high), Mont Ventoux (6,270 feet), and in particular the Haute Provence Observatory at St. Michel, whose 76-inch reflector is the largest telescope in France.

Just outside the path of totality are the cities of Lyons, Toulouse, Montpellier, and Marseilles, where the maximum fractions of the sun's diameter that will be covered are 0.996, 0.991, 0.998, and 0.998, respectively. The 5,000-foot summit of Puy de Dome lies on the northern edge of totality, while not far from its southern limit is Pic du Midi Observatory, 9,400 feet above sea level, provided with a solar coronagraph. There the maximum phase will be 0.976.

Unfortunately, Switzerland lies outside the eclipse track. It has not seen a central solar eclipse since 1912, and will not have another before 1999. But the observatories of Geneva, Lausanne, and Locarno are within 100 miles of totality on February 15th, as is Arosa with its coronagraph. The Swiss Astronomical Society is planning an expedition to Italy.

The largest Italian city within the path of totality is the port of Genoa, which has 723,000 inhabitants. Towns lying not far from the central line include Imperia, Leghorn, Pisa, Arezzo, and Ancona. In the vicinity of the last is Arcetri Observatory, which is equipped with a solar tower and a spectroheliograph. Perugia is situated in the southern half of the Italian zone of totality, while Gran Sasso Observatory, at an elevation of 7,500 feet, lies close to the limit.

Outside the zone are Turin and most of the cities of the Po valley, the largest of which is Milan, 46 miles from the northern boundary. To the south, Rome misses totality by only 38 miles. The last

On this map of southern and eastern Europe prepared by the author, the Universal times of mid-eclipse for points along the central line are given at 10-minute intervals. This is the first occasion in several years that an eclipse track will pass over many fully equipped observatories.

two cities both have major observatories: Rome's station on Monte Mario has solar research as one of its specialties.

In the mountains of Yugoslavia, it will be possible to view the eclipsed sun higher in the sky, from such places as Mostar, Sarajevo, and Nis. The capital city, Belgrade, has a large observatory but lies 25 miles outside the path of totality. Farther to the east are two of the largest cities for which the sun will be wholly blacked out, Sofia in Bulgaria and Bucharest in Romania. Their populations are 726,000 and 1,237,000, respectively, and at both places there are official observatories. At the port of Constantsa, the central line leaves the Balkan mainland and crosses the Black Sea.

In Russia, the track passes over the Crimea, where there are two adjoining observatories at Simeis and at Partizanskoye, both with coronagraphs. The former station also possesses a spectroheliograph, the latter a solar tower. Farther on, the sun is totally eclipsed at noon at Rostov-on-Don, a city of 600,000 people, where there is a university and an observatory. Extending in a northeasterly direction, the path of totality then goes over the widely separated cities of Stalingrad, Kuibyshev on the Volga River, and Sverdlovsk in the Urals. Finally, the moon's shadow leaves the earth at a remote point in northern Siberia.

The great advantage of the easy accessibility of the eclipse track's western half is to some extent offset by the low altitude of the winter sun, and by the rather small probability of clear skies. In northern Italy, the likelihood of this is generally less than about 30 per cent for a morning at this time of year. Climatological data suggest that more favorable conditions may be expected in the interior of Yugoslavia, and in Bulgaria and Romania. In Russia, however, the weather in mid-February along most of the eclipse path tends to be generally unfavorable.

The bright inner corona, showing crescent-shaped streamers, is evident in this photograph obtained by the author at the end of totality last October 2nd. As the edge of the sun was uncovered by the passing of the moon's ragged limb, Baily's beads appeared, lower right. Above them, also to the right on the moon's edge, prominences are visible; to the unaided eye, their fine red color contrasts markedly with the corona's soft hue. An exposure of about 1/50 second was used. North is toward the upper right.

QUESTIONS... FROM THE S+T MAILBAG

Q. Why is a radio telescope so named?

A. Because it can detect radiant energy at radio wave lengths from celestial bodies, and has functions that are counterparts of the resolving power and light-gathering power of an optical telescope.

Q. Who holds the record for number of comet discoveries?

A. Jean Louis Pons (1761-1831) found at least 37 comets. He was doorkeeper at Marseilles Observatory in France, and later director at Lucca and Florence observatories in Italy. Elizabeth Roemer tells his story in *Leaflet* No. 371, May, 1960, of the Astronomical Society of the Pacific.

Q. What is albedo?

A. It is the ratio of the light reflected by a body to the light falling on it. For example, the moon reflects seven per cent of the sunlight it receives, so its albedo is 0.07.

Q. How many galaxies are known to belong to the "local group"?

A. Seventeen, according to R. H. Baker's *Astronomy* (1959 edition). These include our own Milky Way system, the two Magellanic Clouds, M31, M32, and M33. Their apparent sizes range from about 12 degrees (the Large Magellanic Cloud) to 10 minutes of arc (two faint galaxies in Leo). Five of them are listed at a distance of 1,500,000 light-years.

Q. Is Serpens one constellation or two?

A. Even though modern star atlases divide Serpens into two parts, Serpens Caput and Serpens Cauda (the head and tail of the snake), separated by Ophiuchus the Serpent Holder, they are together regarded as only one of the 88 constellations.

Q. What causes the moon's libration in latitude?

A. The moon's equator does not coincide with the plane of its orbit, but is tipped about $6\frac{1}{2}$ degrees to it. Thus, at one time in a lunar month the moon's north pole will be tipped $6\frac{1}{2}$ degrees toward us, while two weeks later the south pole will be presented.

Q. Why can there be vibration in a telescope mounted solidly on a heavy pier?

A. Faulty mounting design is the usual source of trouble. Check such things as the tightness of the bearings, their distance apart on each axis, the size of the tube support or cradle, the length of counterweight supports, and the solidity of the tube. Mirror cells and secondary supports must hold these elements firmly in all positions, and even the eyepiece holder must be free of wobble and looseness.

Q. How far north can all of the tail of Scorpius be seen?

A. The stars Eta and Theta Scorpii, in the animal's tail, are at declination −43°, so from places above latitude 47° north they cannot be observed.

W. E. S.

AMERICAN ASTRONOMICAL SOCIETY TO MEET IN MEXICO

The 106th meeting of the American Astronomical Society will be held in Mexico City on August 22-25, the sessions for papers being at the National University of Mexico. The program will include a visit to the Tonantzintla Observatory in Puebla for the inauguration of its new 40-inch telescope. Martin Schwarzschild, Princeton University Observatory, is to give the Henry Norris Russell lecture.

PLANETARIUM SYMPOSIUM

A symposium for planetarium representatives and operators, similar to the meeting at Cranbrook Institute of Science two years ago, will be held at the Cleveland Museum of Natural History on August 28-31. Further information is available from Dan Snow, Cleveland Museum of Natural History, 10600 East Blvd., Cleveland 6, Ohio.

OBSERVING THE SATELLITES

Sputnik IV

ON MAY 15th, Soviet scientists announced the successful launching of the first full-scale test satellite for manned spaceflight. This five-ton spaceship carried a heavier payload than any previous one – a pressurized cabin weighing some 5,500 pounds and large enough to accommodate a man, together with 3,256 pounds of instrumentation and a power supply.

The May 15th date coincided with the second anniversary of the launching of Sputnik III, which descended into the atmosphere, after some 10,035 circuits around the earth, on April 6, 1960, shortly after 08:00 Universal time. Lunik III, which slipped into an earth orbit after photographing the far side of the moon, was also probably down when Sputnik IV was fired, but had been a lost object for many months.

Sputnik IV's experimental cabin was outfitted with a complete life-support system, and means were provided to separate it from the spacecraft on ground command. However, the Russians said they did not intend to retrieve the cabin from orbit, but that after separation it would burn up in the atmosphere.

As in previous launchings, there were no announcements of the precise time and place of the firing, nor were characteristics of the booster disclosed. The many widely speculative comments in the press about 1960ε1 are the result of lack of information.

The orbital inclination of the newest Russian satellite, and its spent carrier rocket 1960ε2, was 64.89 degrees to the earth's equatorial plane, closely resembling earlier Sputniks. When the problems of prolonged manned orbital flight are considered, inclinations near this value have a slight advantage in that the argument of perigee, which initially amounted to about 62.74 degrees for these objects, changes only slowly with time. Thus, if most of the cosmic radiation trapped in the Van Allen belts is first avoided at apogee, there is less concern that the motion of the line of apsides will carry the apogee to more dangerous geomagnetic latitudes.

For both Sputnik IV and its rocket carrier, nearly circular and relatively low orbits were attained, the farthest distance being about 236 miles from earth, nearest about 196. At first the period of 1960ε1 amounted to 91.22 minutes, while one second more was needed for 1960ε2 to complete a revolution.

Initially, the satellite could be observed in the twilight sky near latitudes north of +33° and south of −60°, but it was hidden by the earth's shadow at intermediate latitudes. Within a few days, by the time the cabin separated, the first of these limits had moved northward to +41°. Afterward, therefore, the satellite was unfavorably placed for photography by the Smithsonian Baker-Nunn camera stations, which are all located between latitudes 32° south and 36½° north. Consequently, the observations during the events following cabin ejection were made by radar installations reporting to the National Space Surveillance Control Center (Space Track) and by Moonwatch observers in northern latitudes.

Soviet press reports stated that Sputnik IV's research program was completed after about four days of flight; it was said that the orientation system and the air-conditioning and thermo-regulating equipment had worked normally, insuring conditions required for future human spaceflight. While the radio arrangements had in general performed successfully, much distortion had been encountered in audio signals relayed by a transmitter working at 19.995 megacycles. Normal operation was reported for the power supply, consisting of chemical batteries and automatically oriented solar cells.

The account given by Tass, the Soviet news agency, of the ensuing events was the following: "A command signal for descent from the orbit was transmitted [at 23:52 UT on May 18th] to the satellite ship, switching on its retro-engines and pressurized-cabin ejection mechanism.

"The retro-engine installation worked normally. . . . However, due to a breakdown . . . in one of the instruments of the satellite-ship's orientation system, the retro-impulse was directed with a deviation from the calculated course. As a result, the ship's velocity was not reduced, but increased, and the satellite ship entered on a new elliptical orbit lying almost in the same plane as the initial, but with a much greater apogee.

"The pressurized cabin was ejected from the ship, and the instruments registered the normal working of the cabin-stabilization system. . . . The signal radio transmitter installed on the satellite ship continues to function. . . ."

Space Track and Moonwatch data suggest that the cabin, 1960ε1, is now accompanied by seven parts of the ship, all traveling in nearby orbits.

Midas II

A SATELLITE designed to detect the launching of ballistic missiles was sent aloft from Cape Canaveral, Florida, on May 24th at 17:36:45.8 Universal time. This object is called Midas II; in the first shot of the series (on February 26th), the stages had failed to separate after successful operation of the booster.

The name is condensed from Missile Defense Alarm System, and is a project of the Air Force's Ballistic Missile Division. The device will use infrared sensors to detect heat from exhaust flames of ascending rockets. When fully operational, the sensors will discriminate among different sources of heat. One objective of the Midas II experiment is to determine the frequency with which nonrocket interference is encountered.

Magnesium flares were to be set off on the ground at Edwards and Vandenberg Air Force bases, both in California, to serve as test objects, and scheduled missile launchings were also to be observed. However, a malfunction in the Midas II instrument command system made it highly unlikely that this could be done.

Both the total weight placed in orbit – some 2½ tons – and the payload weight, about 3,000 pounds, are the heaviest yet achieved by the United States. An Air Force Atlas ICBM, built by Convair, is combined with Lockheed's Agena, originally developed for the Discoverer series, in the Midas launching system. As modified for the purpose, the 130-ton Atlas stands 77 feet high and is powered by two booster engines, a sustainer, and a pair of vernier rockets. All together, these Rocketdyne engines develop some 360,000 pounds of thrust.

Control of the engines is through a new General Electric-Burroughs radio-command guidance system that continuously compares measured position and velocity with a prerecorded flight program. It computes the necessary corrections and changes the alignment of the gimbaled thrust chambers. After the vehicle reaches a predetermined point, the computer initiates separation of the first stage, and the Agena coasts to the proper altitude.

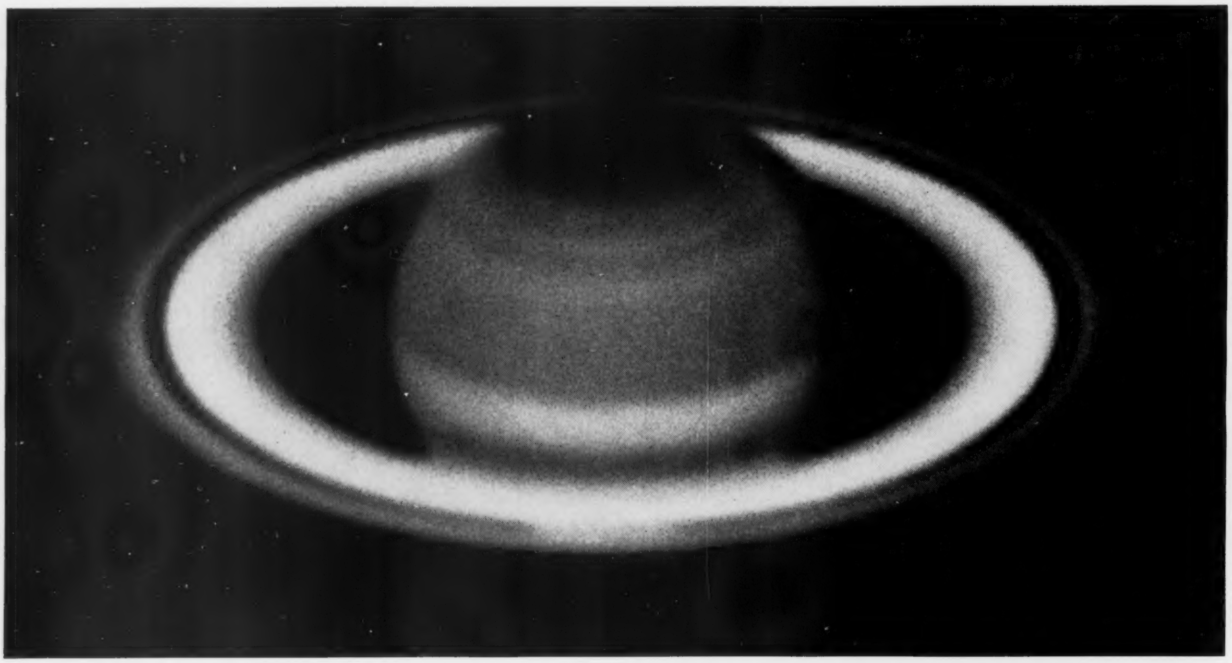
A programmer starts the Agena engine, which operates until orbital velocity is reached. At this time the 15,000-pound-thrust Bell engine is shut off and the entire Agena – about 22 feet long and five feet in diameter – enters into orbit. Its orientation system tips it over into a nose-down attitude, giving its infrared sensors a clear view of the earth.

The major advantage of the Midas is the increase in warning time over the 15 minutes to be given by the Ballistic Missile Early Warning System (BMEWS). If enough Midas satellites were in orbit, this time could be doubled. A related Air Force project, Samos, is designed for detailed general reconnaissance.

The launching of Midas II southeastward from Cape Canaveral resulted in an orbital inclination of 33.0 degrees for 1960ζ. Future Midas shots will be from a new base at Cape Arguello, near Vandenberg Air Force Base, and will strive for polar orbits.

According to data released by Space Track, the initial nodal period was 94.45 minutes, with perigee and apogee at 302 and 324 miles, respectively. Over-all responsibility for operation of the Midas system belongs to the Air Force Satellite Test Center in Sunnyvale, California.

MARSHALL MELIN
Research Station for Satellite Observation
P. O. Box 4, Cambridge 38, Mass.



When this photograph of Saturn was taken with the 100-inch Mount Wilson telescope, the rings were opened to nearly their widest extent. The ring system is 171,000 miles in outer diameter, and consists of a swarm of separate tiny moonlets. The crepe ring is only visible in this picture as a dark arc in front of Saturn's disk.

Planets with Rings

Otto Struve, *National Radio Astronomy Observatory**

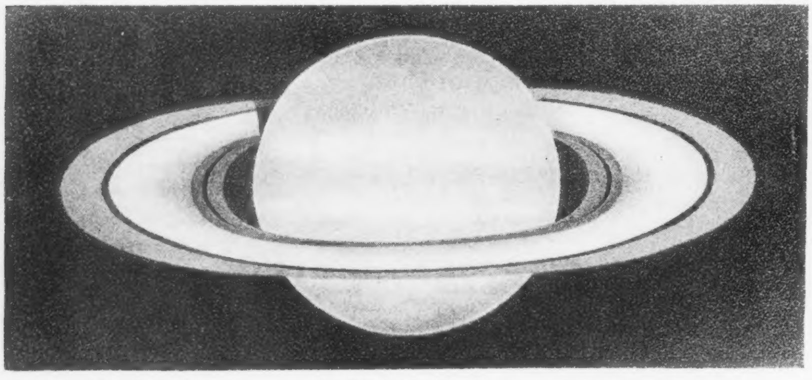
RECENTLY the Soviet astronomer S. K. Vsekhsviatsky, director of Kiev Observatory, sent me a copy of a manuscript entitled "On the Possible Existence of a Ring Around Jupiter."

Older astronomers will remember that Dr. Vsekhsviatsky has for many years defended the hypothesis that the comets originated from eruptions on Jupiter and other planets. This idea goes back to J. L. Lagrange in 1814, who was inspired by the work of H. Olbers and K. L. Harding on the orbits of comets and minor planets, but recently it has been criticized by other astronomers, such as A. J. J. van Woerkom in 1948. Nevertheless, it is often useful to reconsider ideas and suggestions that may not appear convincing now, but can still contain important elements of truth.

In his new paper, Vsekhsviatsky deals primarily with two subjects: the likelihood of observable changes in Saturn's rings and the possibility that there is a very tenuous ring of solid particles in the equatorial plane of Jupiter. Neither topic is entirely new. The question of detectable structural change in the Saturnian ring system was much discussed in the second half of the 19th century. G. P. Kuiper mentioned the possibility of there once having been a ring around Jupiter, in his *The Atmospheres of the Earth and Planets,* 1949, page 342.

But the Kiev astronomer has two specific points to make. He believes that the alterations in Saturn's rings suspected a century ago have been progressing steadily, and are apparent in recent observations. Also, he proposes that Jupiter may have a ring of solid particles, too sparsely spread to be observed by reflected sunlight, but opaque enough to produce a shadow on the equatorial zone of the planet itself.

A great deal has been written by visual observers concerning supposed alterations in Saturn's rings. The first comprehensive summary was published in 1852 by my grandfather, Otto Struve, in the *Memoirs* of the St. Petersburg Academy of Sciences. This contained his drawing, reproduced here, of the planet as seen with the 15-



The elder Otto Struve summarized in this drawing an intensive series of observations with the 15-inch refractor of Pulkovo Observatory, made in 1851 from September 19th to October 4th, with powers of 400x to 700x.

*Operated by the Associated Universities, Inc., under contract with the National Science Foundation.

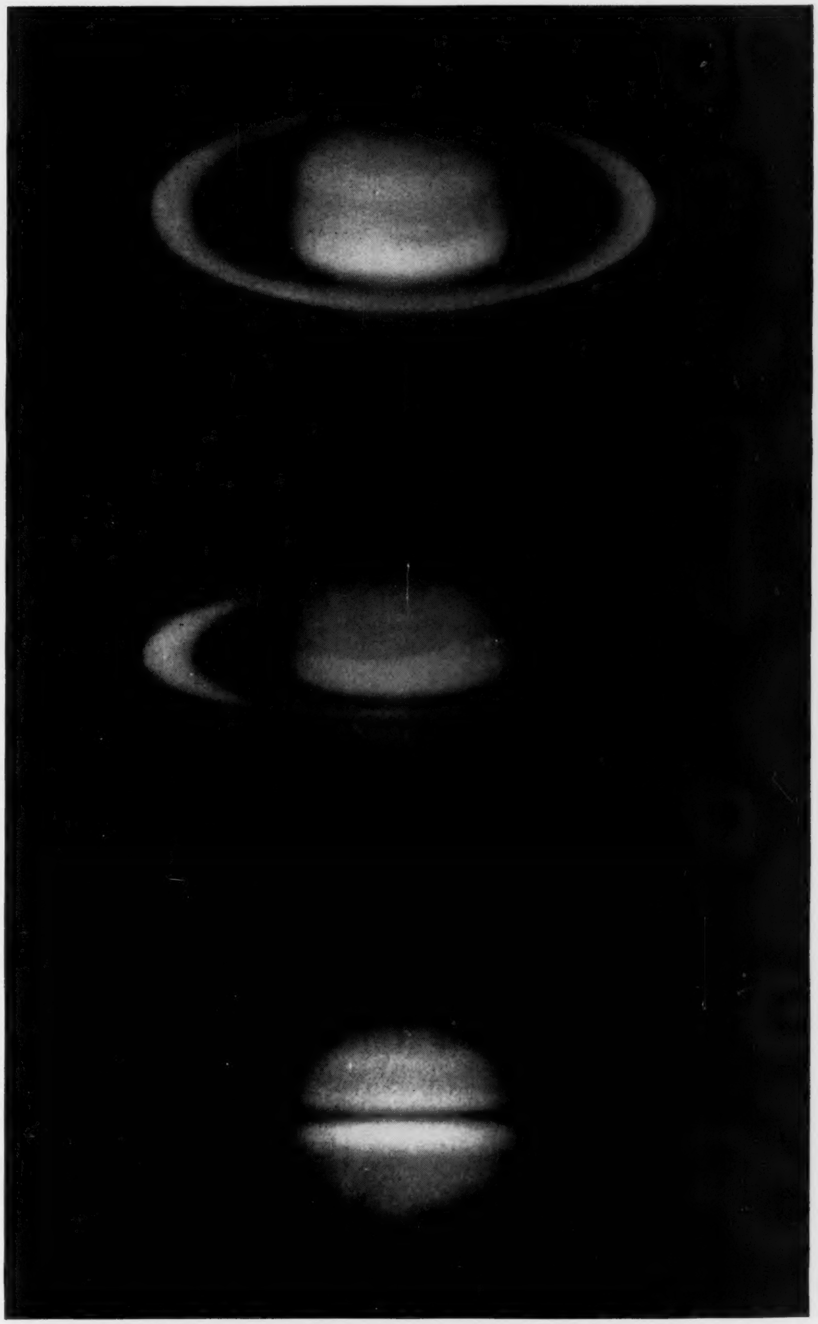
inch Pulkovo refractor in September and October, 1851. It shows very distinctly the outer ring A, which is separated by the dark Cassini division from the bright middle ring B; within the latter is the much fainter crepe ring C.

Also shown here is another illustration from Struve's memoir, based on observations since 1657. He was struck by the narrowness of the rings in the early pictures, compared with what he himself saw. In fact, it appeared that from 1657 to 1851 there had been a progressive decrease in the width of the gap between the planet and the inner edge of ring B, relative to the combined width of rings A and B.

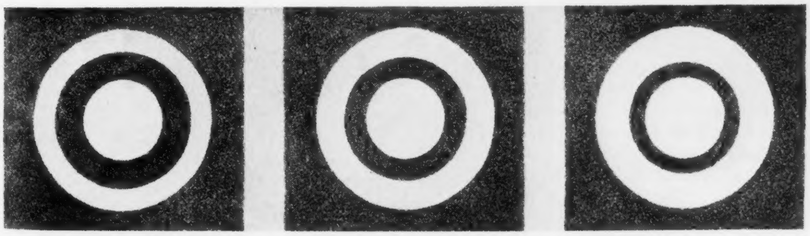
Old drawings and descriptions were used to evaluate this ratio. In 1657, C. Huygens' observations gave 1.41, thus making the bright rings much narrower than the gap. In 1695 it was 1.18, from work of Huygens and G. D. Cassini; while in 1719 J. Bradley found 0.95, and in 1799 William Herschel's measures gave 0.86. With greatly improved instruments, W. Struve in 1826 found 0.64, J. F. Encke and J. G. Galle in 1838 obtained 0.57, while Otto Struve's own measurements in 1851 gave the ratio as 0.49.

Taken at face value, this strongly indicated a rapid approach of the inner edge of the rings toward the planet, the outer edge of A changing little. The first four results, however, were obtained with inferior instruments, and are probably not reliable. But Herschel was an experienced observer, and consideration should be given to his statement made in 1806: "The breadth of the ring is to the space between the ring and the body of Saturn as about 5 to 4." Hence, even if the observations up to 1799 are omitted, rather drastic change is still indicated.

Vsekhsviatsky has attempted to extend the record by means of more recent observations. His table starts with data by A. C. Ranyard in 1883 and ends with measurements made on a drawing published in 1948 in the French book *Astronomie,* by L. Rudaux and G. de Vaucouleurs. But Vsekhsviatsky's numbers cannot be directly compared with the earlier ones, because he attempted to measure from the planet to the inner edge of the crepe ring C instead of to ring B. Nevertheless, the Kiev astronomer concludes that the inner part of the ring system has continued to move in toward the planet.

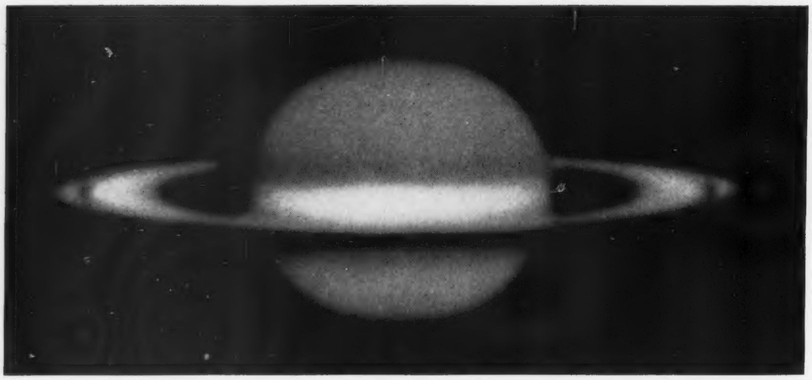


Saturn's aspect changes markedly as its rings are presented more and more edgewise to the earth. These Pic du Midi photographs were taken by H. Camichel, top to bottom, on February 11, 1946, March 6, 1948, and April 15, 1951.



Reproduced from the Struve memoir of 1852, these schematic drawings indicate how the rings would be seen in plan, deduced from observations by C. Huygens in 1657, W. Herschel in 1799, and Struve himself in 1851. Note the apparent shrinkage of the gap between the rings and the planet.

Vsekhsviatsky does not refer to an article by Otto Struve in *Astronomische Nachrichten, 105,* 18, 1883. There the latter reports that measurements made by him in 1882 with the same telescope, and using the identical procedure, gave for the gap-to-ring ratio 0.49 — the same value as in 1851. It was thus apparent that the supposed rapid change in this ratio had not continued after 1851. Moreover,

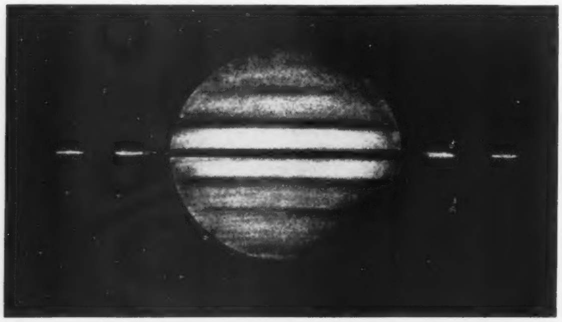


Saturn, photographed in blue light on May 22, 1952, with the 200-inch Hale reflector. Below the rings, their shadow on the planet can be seen, while to the left of the disk is Saturn's shadow on the rings. North is upward. Mount Wilson and Palomar Observatories photograph.

in the years 1885-95 similar micrometer measurements were made by A. Hall with the 26-inch Washington refractor, by E. E. Barnard with the 36-inch Lick telescope, and at Greenwich Observatory with a 28-inch telescope by T. L. Lewis and F. W. Dyson. Again, there was no indication of any decrease in the space-to-ring ratio.

In November, 1895, Lewis published a critical discussion of the whole problem in the *Observatory,* reviewing the papers by Otto Struve and re-evaluating the Huygens observations on the basis of drawings of the ring system rather than measures with his primitive micrometer. Lewis concluded that the ratio of gap to ring for Huygens' work should be taken as 0.91 instead of 1.41, and he discarded completely the Cassini figure in favor of Bradley's good micrometer work.

Commenting on Struve's theory of a steady narrowing of the gap until about 1850, Lewis wrote: "No constant change can be detected in the space-to-ring ratio. . . . One would, however, scarcely



Left: On December 12, 1907, when E. E. Barnard made this drawing with the 40-inch Yerkes refractor, Saturn's rings were seen edgewise.

venture to say that changes do not occur either of a periodic nature or otherwise, as the observations are by no means accordant; but this may be accounted for by the great difficulty in making these measures, and this view is borne out by the greater accordance of recent measures with powerful instruments."

During the present century, there have been very few micrometric measurements of the rings of Saturn, and it is difficult to ascertain whether there has been any change in them. But drawings of the planet have been made, as well as photographs with very large telescopes. On these the edge of the planet and the inner and outer limits of rings B and A are measurable. Vsekhsviatsky notes that great care is needed in comparing visual and photographic determinations of the dimensions, for the fainter parts of the rings and especially the limb of the planet could be lost on photographs in which the contrast is excessive.

With the 40-inch Yerkes refractor, at the turn of the century, Barnard made drawings from which I find the space-to-ring ratio to be 0.51, in agreement with Lewis' value. A photograph that Barnard took in 1911 with the 60-inch telescope on Mt. Wilson gives 0.70, while a later 100-inch picture (page 20) yields a value of 0.75.

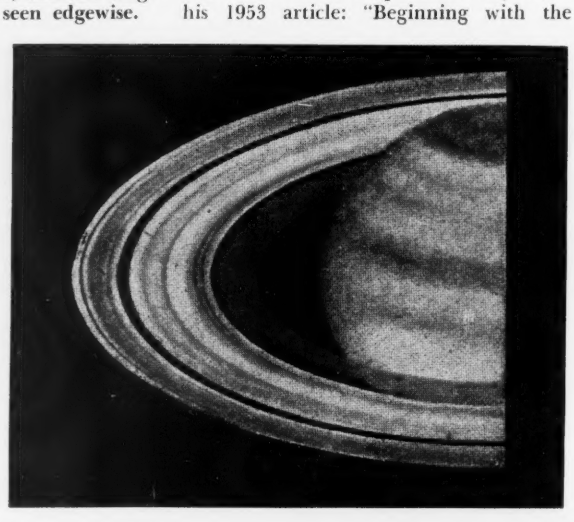
G. de Vaucouleurs has directed my attention to an article by B. Lyot in *L'Astronomie* for January, 1953, where this famous French astronomer shows Saturn drawn with the 24-inch telescope of Pic du Midi Observatory. The drawing was based upon measurements with a double-image micrometer and can be scaled to give the ratio 0.78 for the year 1944. When the 200-inch Hale telescope was used to photograph the planets in 1952, Saturn was observed with the rings nearly edgewise, but the space-to-ring ratio can be measured as 0.68.

If there has been any observable change in Saturn's rings, the ratio has decreased from near 0.86 in 1799 to 0.51 between 1851 and 1900, then increased to approximately 0.75 between 1900 and about 1950. Whether this alteration was real can probably not be ascertained until new micrometer measurements have been made with the same techniques used by the 19th-century observers. Should the change be confirmed, it would probably imply that there is some process that replenishes the ring material, perhaps at irregular intervals, leaving the over-all structure of the ring system approximately the same for centuries at a time.

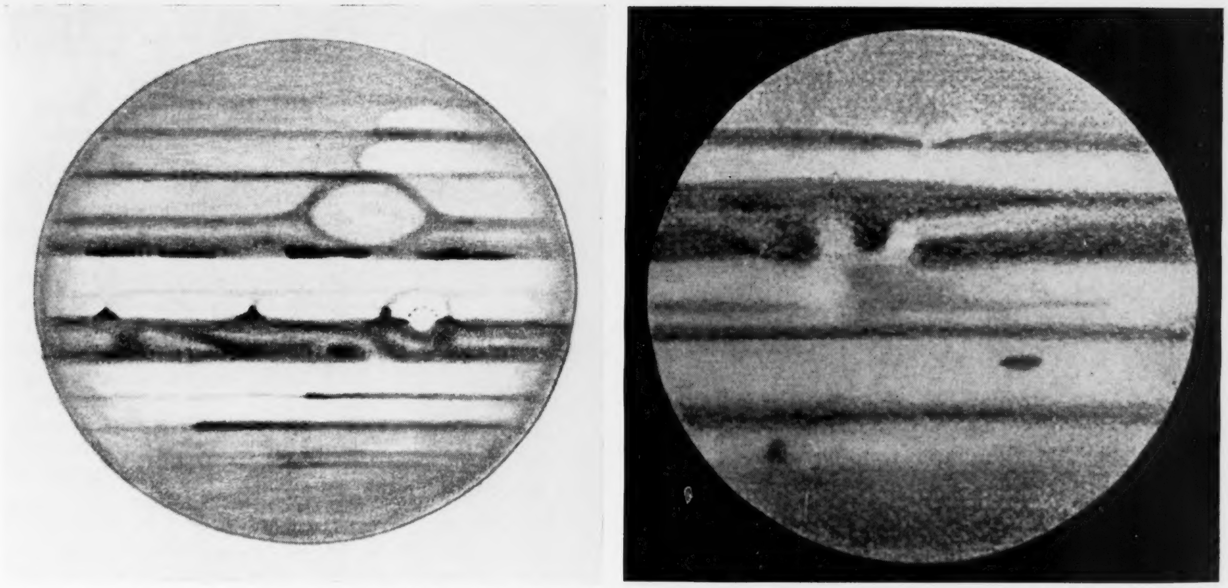
There have also been indications of small changes in the relative brightnesses of the rings and in the conspicuousness of the divisions between them. According to some observers, the crepe ring has been much brighter at certain times than at others. Encke's division in ring A was long regarded as an easily observable feature. But Kuiper reported to the International Astronomical Union that one night in 1954, when the seeing was unusually good with the 82-inch McDonald reflector, he could detect only one clear-cut division — Cassini's, whose width was found to be one-fifth that of ring A.

Kuiper commented: "The other 'divisions' are either minor intensity ripples, with some 10-15% amplitude, or are nonexistent. The Encke 'division' is a ripple where at the same time Ring A changes its intensity abruptly. There are three ripples in Ring B, and there is *no* gap between Ring B and the Crepe Ring."

Contrast that description with Lyot's, in his 1953 article: "Beginning with the



Right: In order to see the fine details shown in this drawing, Pic du Midi astronomers used a magnification of 900 times with the 24-inch refractor. The crepe ring is semitransparent, the planet's disk being faintly visible through it. From "L'Astronomie," January, 1953.



Drawings of Jupiter made more than half a century apart both show a dusky equatorial band. At the left, it is a thin gray line that almost bisects the planet's disk, in Elmer J. Reese's rendition of December 11, 1953, with a 6-inch reflector and good seeing at Uniontown, Pennsylvania. The band is irregular and interrupted in the drawing at the right by the Dutch astronomer A. A. Nijland, with the Utrecht Observatory's $10\frac{1}{2}$-inch refractor on April 25, 1896.

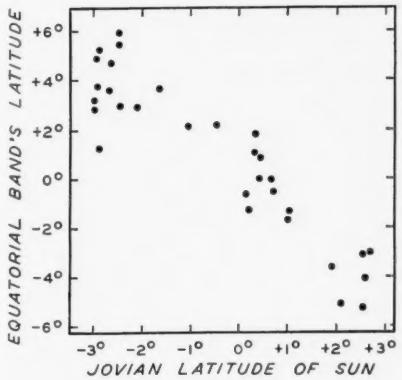
outer edge of ring A, one sees a very brilliant band, about 0.4 second of arc wide, then a narrow black line and another narrow bright zone, followed by a darker belt in which three minima of intensity can be distinguished; next a fairly thin bright zone, and finally Cassini's division."

Lyot continues: "The second ring, B, the brightest of the three, is divided into two almost equal parts by a fairly sharp division. The outer portion of B contains a darkish band, and near its inner edge a double division whose components are separated by only $\frac{1}{4}$ second. That part of the ring between the double division and the central division is the brightest of the ring structure."

The fact that light-scattering particles occur in the so-called ripples suggests that minor alterations are constantly taking place in the rings, as a result of perturbations by Saturn's satellites and perhaps from other causes. Nowadays we are much more receptive than we were a few years ago to the idea that small particles revolving around a planet undergo complicated orbital changes, just as have been observed for artificial satellites moving around the earth.

Perturbations of the particles' orbits must result in collisions and therefore in loss of angular momentum, with a consequent tendency for the particles to spiral in toward Saturn. Since the ring system has existed at least since Galileo first pointed his telescope at Saturn, and probably for a great many centuries more, it is reasonable to believe with Vsekhsviatsky that some process, such as volcano-like eruptions on Saturn, feeds material into the rings, thereby replenishing particles that fall to the surface of the planet.

The second part of Vsekhsviatsky's article discusses the nature of a narrow dark band often observed on the disk of Jupiter, very close to the planet's equator. It is recognized as a real feature in B. M. Peek's recent book, *The Planet Jupiter*, page 97: "Threading its way, nearly along the middle of the zone, telescopes of moderate aperture will often reveal the thin, faint, dusky line, known as the Equatorial Band. Sometimes this will run right across the visible disk; more often it is fragmentary and it seldom encircles the planet. On the two occasions for which latitude measurements are available the Equatorial Band lay within 1° of the true equator; if, however, its placing upon drawings is to be relied upon, this is by no means always the case, though its departure from the equator is naturally never pronounced."



This graph, correlating the latitude of Jupiter's equatorial band with that of the sun, seems to support the Vsekhsviatsky theory that the band is the shadow of a ring of particles.

Vsekhsviatsky correctly points out that the plane of Jupiter's equator is inclined so slightly to its orbit and to the ecliptic that we would never see an equatorial ring widely opened, as we often do in the case of Saturn. Thus, if we were ever to observe a hypothetical ring of Jupiter by the sunlight its particles scatter, the best we could expect would be a view resembling Saturn's rings seen edge on. No such luminous phenomenon of Jupiter has ever been detected, but, as the Soviet astronomer suggests, the glare from the planet may wholly mask a very tenuous ring. Even such a ring, though, would cast a shadow upon the disk, and this shadow would not always coincide with the Jovian equator.

He has collected a large number of measurements, mostly from drawings, giving for each date the latitude of the equatorial band and also the latitude of the sun above or below Jupiter's equator. Unless these tabular data are vitiated by some unknown cause, they indicate an inverse relation between the two quantities: When the sun is north of Jupiter's equator, the band is south, and vice versa. If this result can be taken seriously, it would strongly support Vsekhsviatsky's opinion that the band is not a cloud formation but the shadow cast by a tenuous ring.

Because the equatorial band is not always uniform, being occasionally fragmentary in appearance, Vsekhsviatsky argues that the hypothetical Jovian ring is nonuniform, and contains regions of greater and lesser density. As seems possible in the case of Saturn, the ring may be somehow replenished to replace the particles that perturbations cause to fall to the planet's surface.

AMERICAN ASTRONOMERS REPORT

Here are highlights of some papers presented at the 105th meeting of the American Astronomical Society at Pittsburgh, Pennsylvania, April 18-21, 1960. Complete abstracts will appear in the Astronomical Journal.

Solar Cosmic Rays

A great cosmic ray storm followed a flare on the sun February 23, 1956, and the characteristics of the storm indicated that some of the cosmic particles had been reflected back to the earth after passing several astronomical units outward from the sun. It was as if the sun were surrounded by a field-free cavity with a magnetic border or barrier far outside the earth's orbit.

University of Colorado astronomers G. A. Newkirk, J. W. Warwick, and H. Zirin proposed a simple explanation of this condition, likening the sun to many other stars in this respect. It is surrounded by a sphere of ionized hydrogen at least several astronomical units in diameter, and beyond this H-II region there is a transition zone of roughly the same thickness. The H-II part is much hotter than the H-I (neutral hydrogen) outside, and if the latter is permeated by the general galactic magnetic field, pressure balance would insure virtually zero field in the H-II region.

There would be a kind of magnetic shell at the transition region, which would produce the observed reflection of outgoing solar cosmic rays.

Stellar Populations

A fresh approach to the problem of stellar populations was discussed by Wilhelmina Iwanowska, of Perkins Observatory, who is in this country on leave from the Observatory of Copernicus University in Torun, Poland. In her scheme, which

One of the speakers at Pittsburgh was Wilhelmina Iwanowska of Poland, an authority on stellar astronomy.

reflects recent trends of astrophysical thought, red or blue giants, dwarfs, white dwarfs, planetary nebulae, novae and variable stars, are not uniquely associated with one population type.

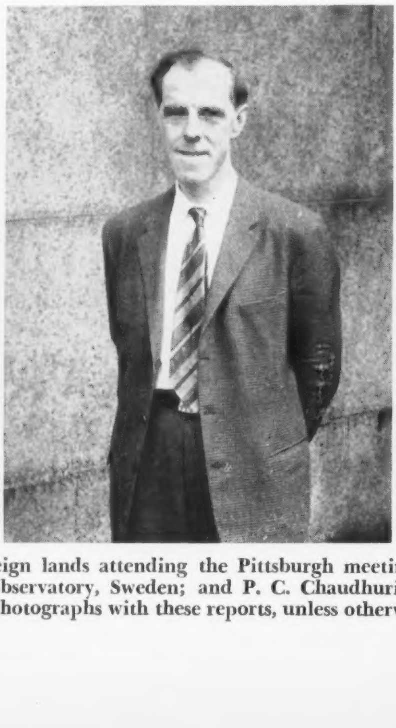
Stars would be assigned to Population I or II according to their probable origin in one of the two main condensations of matter in the galaxy: the disk with spiral arms in it, or the central spheroid. A star's present state and condition would result from its initial characteristics (the population type) and its age, with the star's mass important in determining its physical and chemical evolution and its motions.

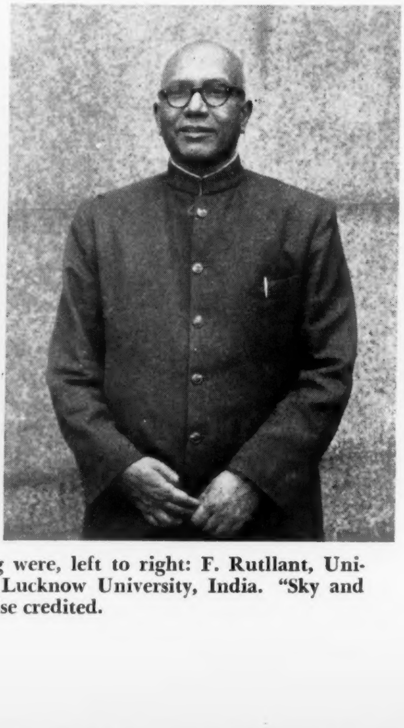
This scheme would allow star formation to go on at present for both types, instead of just Population I. For Population II, however, we know very little of what takes place in the galactic nucleus, or in globular clusters or elliptical nebulae. But there is evidence that in such locations younger, more massive stars do exist along with interstellar gas.

Metallic-Line Stars in Binary Systems

Some stars of spectral type *A*, while having the hydrogen Balmer series as the most intense absorption lines in their spectra, also exhibit relatively strong lines of the metals. Several astronomers have suspected that a large percentage of these metallic-line stars may be members of spectroscopic binaries. At Kitt Peak National Observatory, Helmut A. Abt has made a systematic study of 25 metallic-line *A* stars, picked effectively at random, to test this possibility.

An average of 11 spectra for each star, at dispersions of 18 to 20 angstroms per millimeter, was obtained with the McDonald Observatory 82-inch reflector (coude focus) and the Mount Wilson 60-inch Cassegrainian spectrograph. Only four of the 25 stars were found to have constant radial velocities, the other 21 being definitely spectroscopic binaries. Twelve of these showed double lines, that





Among the many astronomers from foreign lands attending the Pittsburgh meeting were, left to right: F. Rutllant, University of Chile; C. Schalen, Uppsala Observatory, Sweden; and P. C. Chaudhuri, Lucknow University, India. "Sky and Telescope" photographs with these reports, unless otherwise credited.

is, the spectra of both components could be seen. For 15 pairs orbits have been computed, but in six double-lined binaries the line separations were generally too small for good measurements of their periodic shifts.

Even the four stars with constant radial velocities might be double stars, their orbits lying near the plane of the sky, or their motions too slow to show line shifts, or the observations incomplete. Therefore, Dr. Abt believes, from the high percentage of spectroscopic binaries in his 25 cases, that all metallic-line *A* stars are members of binary systems. The periods of revolution he found have a wide range, from one to 361 days.

The Venus Greenhouse

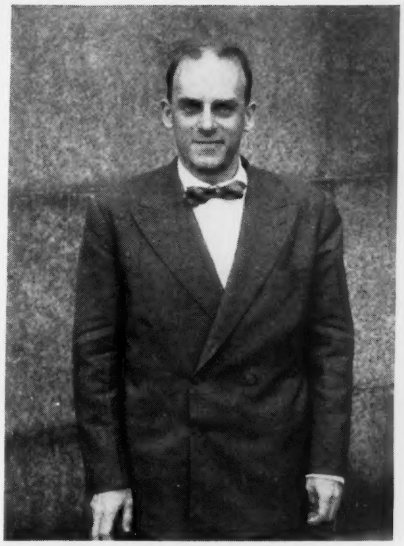
Radio observations of Venus at centimeter wave lengths indicate that beneath its thick layer of clouds the planet has a surface temperature of about 600° Kelvin (620° Fahrenheit). It is evident that the Cytherean atmosphere produces a marked greenhouse effect, for an airless planet at Venus' distance from the sun would have a radiation temperature of about 250° K., if its rotation period were short compared with its revolution, and about 100 degrees higher than that if the two periods were comparable.

At Yerkes Observatory, Carl Sagan has

Nicholas E. Wagman, director of Allegheny Observatory, was host to the meeting. Photo by W. K. Hartmann.

computed the properties of the Venus atmosphere on the basis of 600° surface temperature. The near equality of temperatures on the planet's day and night sides, and the banded pattern of its atmosphere, suggest rapid rotation and indicate very high absorption of radiation by its atmosphere at long wave lengths. In fact, nearly complete absorption would have to extend from 1.5 microns in the infrared to the very long waves at 40 microns.

The only likely molecule with absorption bands in the region longward of 20 microns is water, which would be in the form of steam, requiring one to 10



B. Pagel, left, of Royal Greenwich Observatory, England, and J. Meffroy, Montpellier University, France, pose outside the Mellon Institute.

grams per square centimeter area to account for the strong greenhouse effect. Carbon dioxide should also play an important role. An ice-crystal layer should form about 23 miles above the planet's surface, where the temperature would be about 43° centigrade below freezing.

The Yerkes astronomer pointed out that the earth would have developed an atmosphere resembling that of Venus had it been placed in that planet's orbit very early in its evolutionary history.

New Polarization Measurements of the Solar Corona

Very accurate measurements of the polarization of the sun's corona have been obtained at the total eclipse of October 2, 1959, by University of Minnesota scientists. Their equipment was used successfully at two sites in the Sahara Desert, while at a third location along the path of totality weather conditions were poor.

The scientific team consisted of W. F. Huch, P. J. Kellogg, R. W. Maas, and E. P. Ney. They adapted television cameras for use on telescopes, with photomultiplier tubes as detectors, and were able to measure with only five-per-cent error the absolute intensities of polarized and unpolarized light from the corona. The direction of the polarization angle could be found within 0.8 degree. During the brief time of totality, five complete scans of the eclipsed sun were made in two wave lengths, 4500 angstroms in the blue and 8500 angstroms in the infrared region of the spectrum.

They reported analyses of three of the scans. The measurement of polarized and unpolarized light allows separation of the coronal light into its two parts, the F corona caused by dust that scatters sunlight (as in the zodiacal light), and the K corona coming from scattering by free electrons in the sun's outermost atmosphere.

The direction of the polarization in the sense of the magnetic vector in the electromagnetic wave was found to be radial within ±1°. This shows that the light of the K corona is scattered, and has a negligible contribution at these wave lengths from synchrotron radiation. The results therefore did not substantiate a theory Drs. Kellogg and Ney had previously proposed, that the corona might consist of charged particles trapped in a magnetic field and producing synchrotron radiation.

Three government agencies supported this program: Office of Naval Research, National Science Foundation, and National Aeronautics and Space Administration.

Radio astronomer V. V. Vitkevitch, from the Physical Institute of the U. S. S. R. Academy of Sciences.

Amateur Astronomers

NORTH-CENTRAL CONVENTION

THE senior and junior societies of Madison, Wisconsin, were hosts for the 14th annual North-Central regional meeting of the Astronomical League, May 21-22. Sessions were held at the University of Wisconsin.

After a welcome from Dr. Arthur D. Code, head of the university's astronomy department, Charles H. Giffen spoke on novalike variable stars, and Tim Wyngaard told of his experiences with the American expedition to the Canary Islands for the total solar eclipse last October. At the instrument session, Craig Shurr described a portable telescope, Harold Watson the need for quality amateur instruments, and Phil Gloser the construction of a filar micrometer.

There were talks on observing, followed by a question-and-answer period with a panel of experts, and a time-lapse color movie of the planets taken through Mount Wilson Observatory's 60- and 100-inch telescopes. The convention banquet speaker that evening was Dr. C. M. Huffer, University of Wisconsin, on "Astronomy and Scenery in Arizona."

A junior session was held Sunday morning, after which there was a field trip to Pine Bluff Observatory to inspect the 36-inch reflector. Next year's meeting will be held in Urbana, Illinois.

JOSE HERNANDEZ
529 Mackubin St.
St. Paul 3, Minn.

COCOA, FLORIDA

Formed a year ago by three juniors, the Central Brevard Junior Astronomical Society now has eight members and has joined the Southeast Region of the Astronomical League.

The club meets biweekly at 7:30 p.m. Thursdays at the home of its advisor, Mrs. A. L. Kleinfeldt, 1205 Montclair Rd., Cocoa, Fla. There is usually observing with the group's five telescopes, the largest of which is an 8-inch reflector built by Mrs. Kleinfeldt.

Correspondence with other junior societies, exchanging project news and ideas, is welcome.

WESTERN AMATEURS CONVENTION NOTES

"Astronomy Advances with Amateur Assistance" is the convention theme of the Western Amateur Astronomers meeting at San Jose, California, August 23-27. Cosponsors are the San Jose Amateur Astronomers and the Peninsula Astronomical Society.

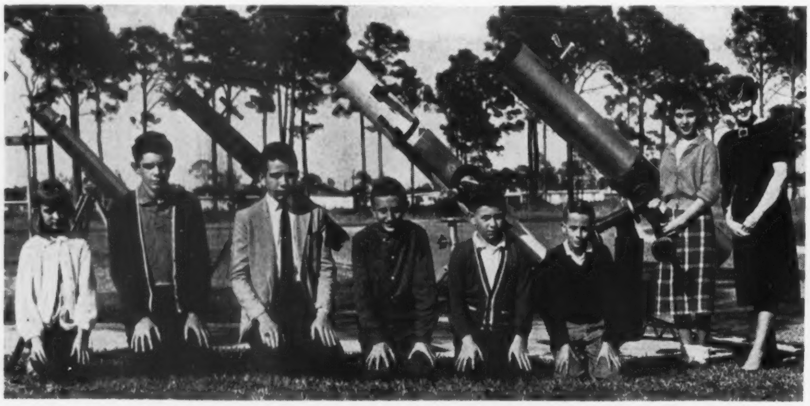
Sessions will be held at the San Jose municipal auditorium, which is diagonally across the street from convention headquarters, the St. Claire Hotel, located at San Carlos and Market streets. Field trips are planned to Lick Observatory, Ames Research Center of the National Aeronautics and Space Administration, and Stanford University's radio research installation.

Until August 23rd, registration is \$2.50 per person or \$4.00 a family, and may be sent to Mrs. E. Pollock, 4460 Columba Dr., San Jose, Calif. Display space is available from E. Kingman, 2407 Woodland Ave., San Jose, Calif., while Robert T. Jones, 840 Lincoln Ave., Palo Alto, Calif., is in charge of program-time requests.

NEW HAMPSHIRE AMATEURS

Dr. Harlow Shapley, former director of Harvard Observatory, was guest speaker at the first statewide meeting of New Hampshire amateur astronomers on May 14th. Thirty-five persons from societies in Manchester, Nashua, and Keene attended the lawn party, sponsored by the Manchester Astronomical Society at the home of one of its members in Merrimack.

DAVID E. PICKERING
R.F.D. 2
Reeds Ferry, N. H.



Members of the Central Brevard Junior Astronomical Society. From left to right: Diane Lloyd, Perry Butler, Charles Spieth, David Larimer, Peter Braden, Arthur Lloyd, Jean Lloyd, and Mrs. A. L. Kleinfeldt.

+++ AMATEUR BRIEFS +++

The Amateur Astronomers Association of New York City, the largest local society in the country, has applied for membership in the Astronomical League. It becomes the 35th group to belong to the Northeast Region.

Potluck. For their May meeting, the Portland (Oregon) Amateur Telescope Makers and Observers were asked to "bring your wife, some food, your eating equipment. . . . If your name begins with a letter from A to L, bring a hot dish for dinner; if M to Z, a salad."

Summer courses in astronomy are being given in Wheeling, West Virginia, and Charlotte, North Carolina. Friday evening sessions are offered at the Speidel Observatory of Oglebay Institute in Wheeling, while the Charlotte Amateur Astronomers' Club is sponsoring 8 p.m. classes at the Children's Nature Museum on July 11th, August 9th and 16th.

Jerry Logan discusses making fiberglass telescope tubes in the May *Star Gazer* of the Bergen County (New Jersey) Astronomical Society. "If made properly, the tube will be as strong as aluminum, but only two-thirds the weight. The simplest way . . . is to put the fiberglass on a cardboard tube."

On May 12th, two days after celebrating the 11th anniversary of its opening, the Morehead Planetarium at Chapel Hill, North Carolina, welcomed its millionth patron, Ann Causey, a 4th-grade student from Greensboro. She received appropriate astronomical gifts from the director, A. F. Jenzano.

Other amateurs might consider the suggestion made in the *Galactic Report* of the Junior Astronomy Club, New York City. "When observing this summer, make two copies of your observations; one for yourself and one for the club."

Hot weather item. From the *Star Dust* of the Astronomical Society of Harrisburg, Pennsylvania: "The absence of any report from our group in SKY AND TELESCOPE about the recent lunar eclipse is unfortunate. Surely we got as cold as anyone else did."

The Redlands Astronomical Society, in San Bernardino, California, recently changed its name to the Valley Amateur Astronomers. Mrs. E. Patterson, 2842 Fremontia Dr., San Bernardino, Calif., is the secretary.

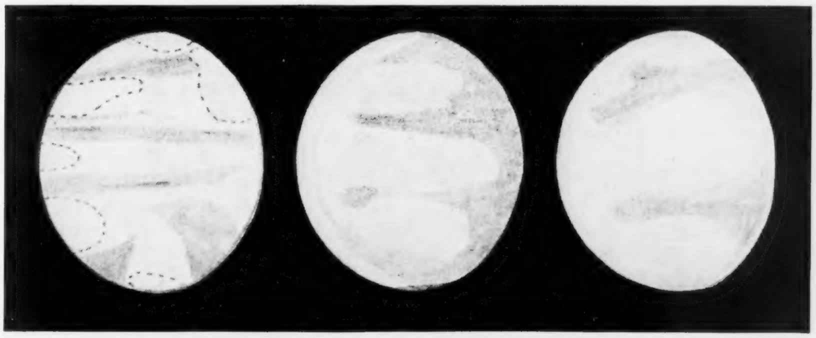
Information about the five-member San Diego Astronomical Society may be secured from its president, Daniel A. Poole, Jr., 1601 Robinson Ave., San Diego 3, Calif.

The Cincinnati (Ohio) Astronomical Society adds to its collection of astronomical slides by inviting members to try their hand at astrophotography with one of the society's telescopes. Available are 14-inch and 16-inch reflectors, an 8-inch refractor, and smaller instruments.

H. M. C.

Getting Acquainted with Astronomy

The Planets — Venus – II



The faint gray shadings of Venus are shown in these 1949 drawings by American amateurs. Left, T. Cragg on July 27th used a 12-inch refractor at 125x for his sketch, where dashed outlines indicate brighter areas. Note the similarity of the markings in the other two pictures, by E. J. Reese on August 7th with a 6-inch reflector, 240x, and on August 9th by C. B. Stephenson using a 6-inch refractor, 200x. The contrasts are exaggerated.

PARADOXICALLY, Venus is the easiest and at the same time one of the most difficult of the planets for telescopic observation, as indicated in our first installment on page 416 of the May issue. The beginner with a very small telescope can enjoy viewing the phases of Venus, especially when the illuminated disk is a crescent, as will be the case next February and March. On the other hand, a serious study of the elusive dusky surface markings by visual means requires much skill and experience on the part of the observer.

The great handicap presented by Venus is the dazzling brightness of its cloud-covered surface. Not only can the glare efface true features, but it gives rise to spurious ones, as a result of excessive contrast with the dark sky. Much of the art of observing this planet consists of distinguishing between actual and false markings, and in minimizing the latter through careful choice of techniques.

Instruments

For systematic studies of the Cytherean surface, many experienced amateurs prefer relatively small telescopes of fine quality — 4-inch refractors or 6-inch reflectors. At these modest apertures, the glare of the planet is less troublesome. With small instruments or large, however, it is much better to observe in twilight or by day, rather than after dark.

Besides lessened glare, the advantages of day observation include the possibility of viewing Venus for hours at a stretch, and at times when it is high above the horizon. Locating the planet in the daytime is easy with setting circles, but these are not essential, as it usually can be found with the unaided eye.

When Venus is a narrow crescent close to the sun, around the date of inferior conjunction, it is very helpful to add a cardboard extension to the telescope. Such a sun shield, two or three feet long, greatly reduces troublesome stray light. Users of portable instruments may take advantage of the shadow of a neighboring building to shield them from direct sunlight. During day observations of Venus, great care must be taken to avoid bringing the sun into or near the field of view, as its blinding dazzle might damage one's eye permanently.

Systematic observers of Venus who use 4- to 6-inch telescopes generally favor powers of 200x or less. Particularly in daytime work, changing to a lower magnification appears to enhance the visibility of surface features. The French planetary expert A. Dollfus points out, however, that spurious dusky markings on the disk are more pronounced with low power, and he recommends 350x or higher to eliminate them, on the basis of his experience with large instruments.

Some Observing Problems

Among the most frequently recorded surface features are brighter patches near one or both cusps of the planet's crescent. These cusp caps undergo well-known alternations in conspicuousness, one or the other sometimes dominating for weeks or months at a time. From a study of 830 observations by 34 amateurs in 1944-56, J. C. Bartlett, Jr., noted that, when only one of the cusp caps is visible, the southern one is reported twice as often as the northern. This is one of the few definite results found for these features, which deserve systematic watching.

Another problem involves discrepancies between the actual and predicted phase of Venus. At western (morning) elongation, the disk appears exactly half-illuminated several days later than predicted; at eastern elongation, this *dichotomy* is observed earlier than expected. Although the effect is conspicuous, it has not been completely explained, and remains a favorite subject for observation by amateur groups. The simplest way to determine the time of dichotomy is to examine the planet daily around the epoch of elongation, noting the date on which the terminator (edge of sunlit portion) appears perfectly straight, rather than convex or concave.

But the phase anomalies are not confined to this. By definition, the phase of Venus is the numerical fraction of the disk that is illuminated. It is also equal to the distance, expressed as a fraction of the planet's diameter, between the bright limb and terminator, measured along the diameter perpendicular to the line of cusps. This distance is easily scaled on careful drawings of the planet, or it may be directly estimated at the telescope. Thus it is possible to compare the observed phase with the predicted (tabulated in the *American Ephemeris*) while Venus is crescent or gibbous, as well as at the time of dichotomy. Some results of this kind may be seen on page 520 of the August, 1958, Sky and Telescope.

Because Venus has a dense atmosphere, when this planet is nearly between us and the sun its thin crescent extends through more than a semicircle. On several occasions, the planet has been seen as a beautiful, complete ring of light.

These appearances are shown in photographs taken in 1940 with a 6-inch reflector by J. B. Edson and a group of California Institute of Technology students. They traveled to Table Mountain,

This day-by-day sequence of Venus photographs was taken in 1940 as the planet was moving past the sun at inferior conjunction, causing the crescent to swing around rapidly. Note that the crescent extends through more than a semicircle, the prolongation being due to refraction and scattering of sunlight in the Venus atmosphere. Photos courtesy J. B. Edson.

California, expressly to observe the inferior conjunction of Venus that June, and secured more than 2,000 photographs over a period of several days. An important finding was of irregularities in the slender cusp extensions, indicating structure in the planet's atmosphere.

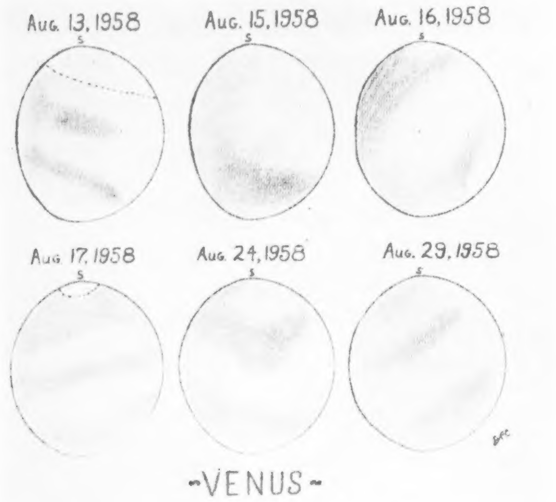
When Venus is within a month or two of inferior conjunction, observers have occasionally noted that the hemisphere not illuminated by the sun nevertheless appears faintly visible. This ashen light, though known for over two centuries, is still imperfectly understood, and is believed by some astronomers to result from auroral activity in the atmosphere of Venus. Systematic records of the visibility or nonvisibility of the ashen light, if they were continued for a long period, would be useful. Existing reports are too scattered to demonstrate, for example, whether or not the rate of occurrence changes during the solar cycle, as we might expect if it were actually an auroral phenomenon.

To see the ashen light, it is helpful to place an occulting bar in the eyepiece for masking the bright crescent. On very rare occasions, the luminescence appears mottled, or extends over only part of the planet's night side.

For visual observers, the dusky markings of Venus are of special interest, despite their difficulty. As Patrick Moore states in his book, *The Planet Venus*, ". . . the surface markings are vague and impermanent. Even the more conspicuous of the dusky shadings on the disk are so elusive that it is almost impossible to fix their positions with any accuracy; moreover, they change so quickly that it is unusual for any particular feature to be identified for more than two or three days running."

It has been demonstrated by model experiments, in which drawings were made of illuminated blank spheres as seen through telescopes, that spurious shadings can appear that closely resemble those on many Venus drawings. Mr. Moore comments: ". . . what may be termed the 'real' dusky shadings are visible only with larger telescopes. I have experimented with various instruments, mainly my 3-inch refractor and 6-inch and 12½-inch reflectors, and have found that when conditions are good the 12½-inch will always show most detail. Nearly always the disk as seen through the 3-inch appears blank."

Some fine drawings of Venus, showing a structure of parallel shaded bands, were obtained in August, 1958, by Dale P. Cruikshank, Des Moines, Iowa, when he had the use of the 40-inch Yerkes refractor. His best results were with the objective stopped down to between 18 and 36 inches, and a power of 550x.



Dale P. Cruikshank made these Venus sketches with the Yerkes 40-inch refractor, at reduced apertures. The dusky shadings were much fainter and more diffuse than as seen here, contrast having been exaggerated for better reproduction. On half the occasions when Mr. Cruikshank viewed Venus with the large telescope, the disk appeared blank, even in good seeing. From the "Strolling Astronomer."

This banded pattern is much more conspicuous on photographs taken with ultraviolet light than it is visually. For the advanced amateur, therefore, a photographic program may prove particularly rewarding. A transmission filter consisting of a thin layer of silver deposited on glass can be used, since it will pass near-ultraviolet light though reflecting longer wave lengths; for the same reason, the telescope mirror should be aluminized rather than silvered. Another technique to be explored is the use of an image converter attached to the eye end of a telescope, to make the ultraviolet markings directly visible.

Methods of Observation

The average amateur, however, will prefer a visual observing program that does not require elaborate accessories. Color filters similar to those for photography are very useful, as they sometimes accentuate indistinct details, such as the cusp caps and vague light or dusky areas. Eastman Wratten filters are excellent for this purpose, and 25A (red), K2 (yellow), X1 (light green), and C5 (blue) can be suggested as a basic set. Some detailed recommendations on applications of filters to planetary observing were given by C. F. Capen, Jr., on page 517 of the August, 1958, issue.

As in planetary work generally, a drawing of Venus is of little use unless it is labeled with the date and time of observation. The record should also include such information as the quality of the seeing and sky transparency, the aperture and the magnification employed, and the apparent disk diameter (from the *American Ephemeris*). The value of a drawing is increased by a word description.

Some observers use a numerical scale for the estimated intensities of different features. The Association of Lunar and Planetary Observers employs a range from −5 for the brightest areas, through 0 for the average of the disk, to +5 for the darkest regions. A different system has been adopted by the British Astronomical Association, ranging from 0 (white) to 10 (black); Venus shadings seldom exceed 2 on this scale.

Amateurs who plan to take up systematic observations of Venus will want to contact others with similar interests. The Venus recorder of the ALPO is Dr. James C. Bartlett, Jr., 300 N. Eutaw St., Baltimore 1, Md. Another active group is the Venus section of the BAA, directed by Patrick Moore, Glencathara, Worsted Lane, East Grinstead, Sussex, England.

Reports of the work done by these groups are published in ALPO's *Strolling Astronomer*, and the *Journal* and *Memoirs* of the BAA. The large number of Venus observations they contain affords much ready-made material for the amateur who has new ideas to test. In this way, someone who does not have the opportunity to make telescopic studies may be able to throw fresh light on some of the many puzzles of Venus.

AUGUST KOPFF

One of Germany's leading astronomers, August Kopff died unexpectedly on the evening of April 25, 1960. He was emeritus professor of astronomy at Heidelberg University.

Born on February 5, 1882, Dr. Kopff studied at Heidelberg and became assistant to Max Wolf at Königstuhl Observatory, where he discovered many asteroids and photographed galaxies. From 1924 to 1954 he was director of the Astronomisches Rechen-Institut (Astronomical Computing Institute), first at Berlin-Dahlem and after the war at Heidelberg. Also, from 1947 to 1950 he was director of Königstuhl Observatory.

As an expert on star positions, Dr. Kopff planned and supervised the construction of the FK3, a catalogue giving extremely precise co-ordinates and proper motions of 1,535 fundamental stars. In addition, he was responsible as chief of the Rechen-Institut for the publication of the Berlin astronomical ephemeris, and for the annual volume of asteroid predictions, *Kleine Planeten*.

OBSERVER'S PAGE

Universal time (UT) is used unless otherwise noted.

Notes on Six Lunar Problems

In this department for March, 1958, there was a list of six lunar formations, in the neighborhood of Mare Nectaris, whose published descriptions were contradictory. I have attempted to answer these questions by the observations reported here.

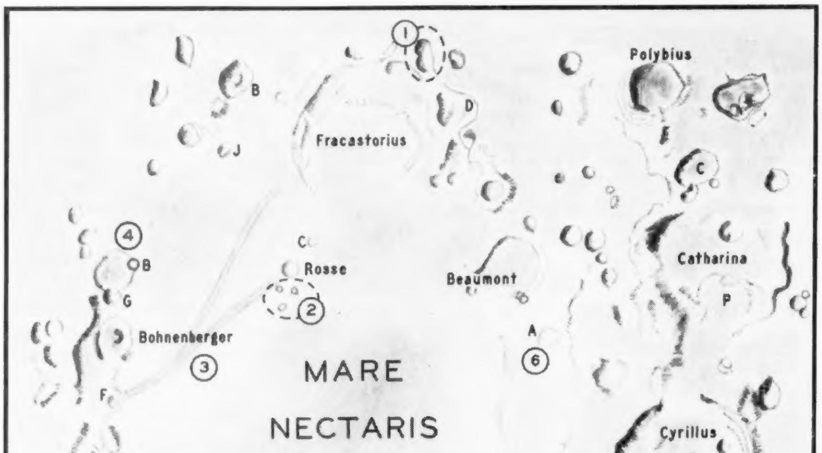
Drawings made at the telescope of the moon's surface often contain too much error and personal interpretation, while photographs taken with amateur instruments are generally lacking in fine detail. Hence, in observing the moon with my 12½-inch reflector, approximately halfway through a period of visual observation I take several negatives through a 7-mm. or 4-mm. eyepiece. The camera used is like the one described by Jack Eastman on page 510 of the July, 1959, issue, and takes 3¼-by-4¼ film, usually Kodak Royal Pan.

Afterward, light 9x enlargements are made from the negatives on G-2 Kodabromide paper. On these, shadows and intermediate densities are increased with B and BB drawing pencils and stumps, and I add visually observed fine details with the same tools. Two examples of such pictures accompany this article. The technique is not new, as J. N. Krieger used it many years ago for his beautiful lunar atlas.

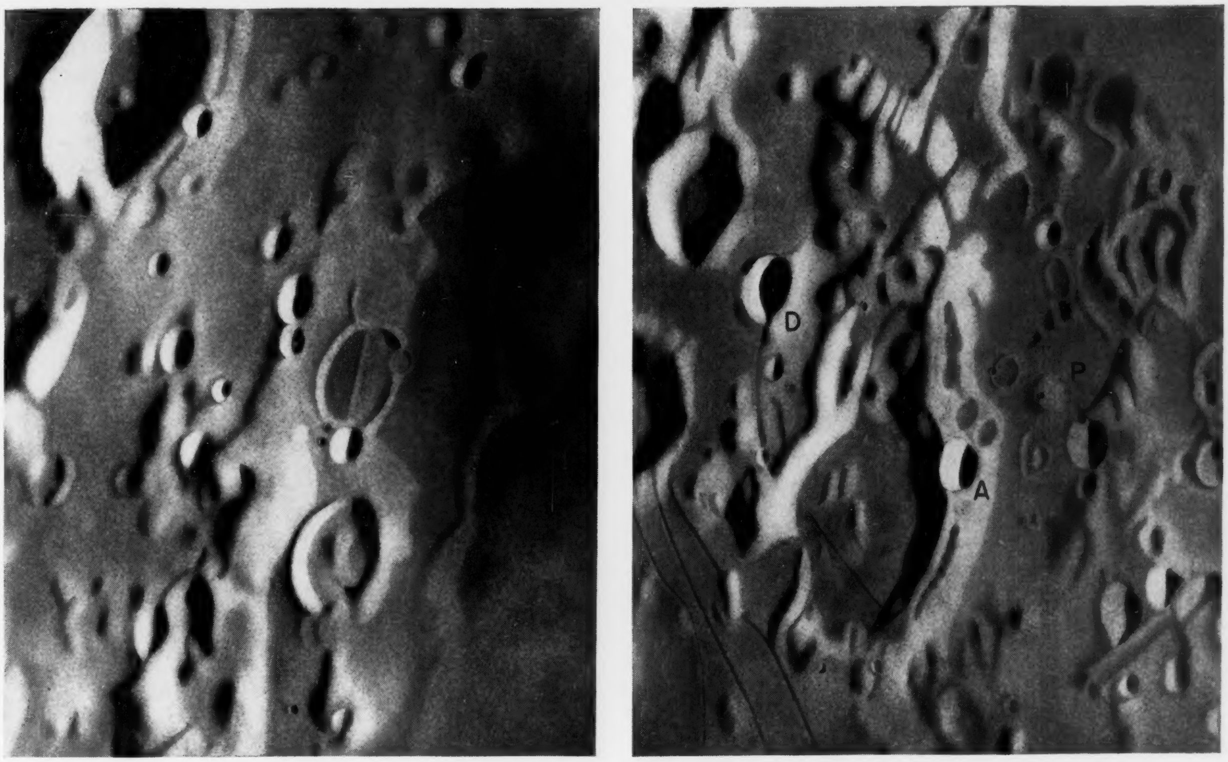
The six lunar formations are listed here by the same numbers as in the 1958 article.

1. The nature of the feature *Fracastorius Y* was in doubt. My observations show that under a morning sun (colongitude 329°) it appears as a narrow valley. Under an evening sun (colongitudes 129° and 141°) it was seen and photographed as three fused rings, the most northerly being the largest. The southernmost ring is offset to the east of the line formed by the other two.

2. Older maps disagree as to the number and arrangement of minor features in the vicinity of *Rosse*. This crater stands to the south of the junction of two ridges, which trend in a generally northerly direction across Mare Nectaris. Just south of the junction, another ridge runs southwest toward the crater Fracastorius B, and a fourth links the system to Rosse. With poor seeing, two elongated bright elevations (marked **h** on my sketch) were visible on the northern ridges; a pair of craterlets



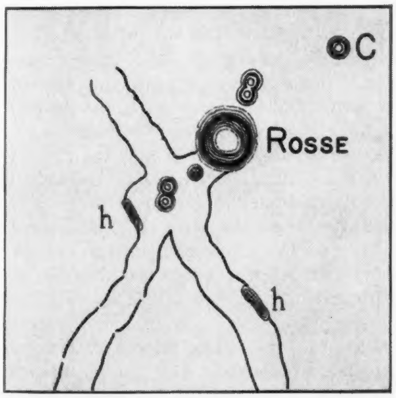
Circled numbers identify the six lunar areas described in S. R. B. Cooke's article, all of which have presented puzzles in interpretation. South is at the top in this key chart, which has been adapted from "Kritische Mondkarte," published in 1941 by H. I. Gramatzki in Germany.



These drawings were made by Dr. Cooke, by the method described in his article, the visually detected details being added to a photograph taken with his 12½-inch telescope on December 18, 1959. Left: the region of Bohnenberger B. The large, low ring just right of center is Bohnenberger A, bisected by a ridge. B is the delicate small ring interrupting the right wall of A. The very large crater at the upper left is Santbech. Right: Gutenberg is the great crater below center, with the deep craterlet A on its right. Above and to the right of A is the small low-walled ring described in the text. Note the system of parallel rills in the lower left portion of this picture.

at the junction; and a crater pit on the fourth ridge. Southeast of Rosse are two fused craterlets.

3. The existence of Neison's *rill Xi* near Rosse has been in doubt. Its southern half was held clearly under both morning and evening illumination (colongitudes 329° and 141° respectively). It appeared in the form of an enormous integral sign lying under the ridge from near Bohnenberger F to the northwest wall of Fracastorius.

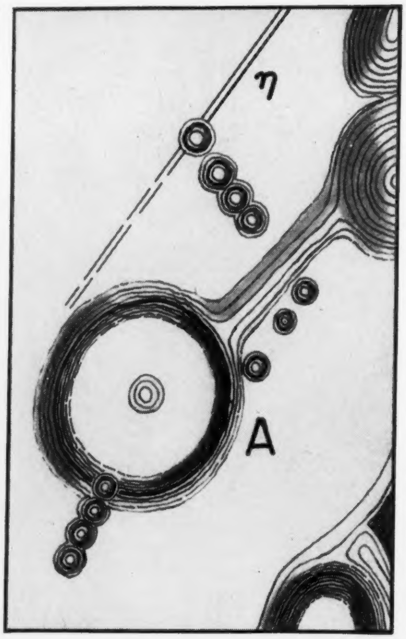


The environs of the crater Rosse, as observed by the author with a 12½-inch reflector. Rosse is six miles across, and Rosse C two miles. Two raised areas are labeled "h." In all pictures with this article, south is above, and east is to the right.

4. Mädler's crater *Bohnenberger B* has been missed by some later observers. It was seen at colongitudes 329° and 129° as a nearly circular ring, occupying the gap in the east wall of Bohnenberger A. The walls of B are low, the eastern section being higher than the western, which obtrudes on the floor of A. Both craters have floors of the same hue, and lighter than the mare to the east. Just south of B, the rampart of A casts a pronounced shadow. As the drawing indicates, A is divided in half by a meridional ridge, the floor to its west being darker than to the east. Just west of the conspicuous small crater Bohnenberger G are two little pits and a white spot.

5. The question has been debated whether the *object just southeast of Gutenberg A* is a crater or merely a shallow depression. My inspection showed that it has a flat floor and a low, thin wall. A craterlet interrupts the west wall, but otherwise the object is like Bohnenberger B.

In the accompanying drawing of this area are other features meriting observation. P is a plain partly enclosed by hills



Beaumont A's central hill is conspicuous in Dr. Cooke's drawing with his 12½-inch reflector. There had previously been some uncertainty whether this feature existed. Beaumont A itself is about five miles across.

and mountains, whose north part is occupied by a gently swelling object similar to a dome, with a central summit pit. South of P is a shallow, elongated depression, with no perceptible walls, resembling the saucers in Ptolemaeus.

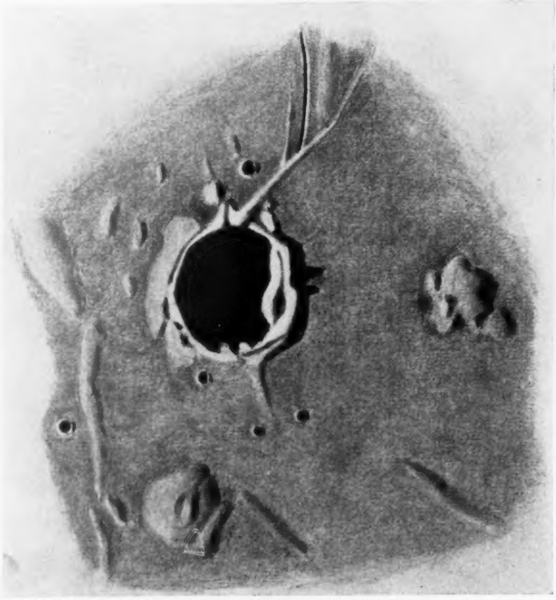
The crater D, northeast of Magelhaens, has a partly breached west wall. Running from the north end of D is what seems a rill, not shown on any map, extending to the west wall of Gutenberg. Though perhaps merely an escarpment, if prolonged eastward it would meet the western end of the well-known rill crossing the floor of Gutenberg, shown in part in the drawing.

6. Authorities have disagreed whether the crater *Beaumont A* has a central summit. Shortly after sunrise on this part of the moon, I could see a low round central hill, there being no question of its reality. With a somewhat higher sun the central hill was invisible, even though the seeing was much better and many more craterlets were detected. The wall of Beaumont A is highest on the east, and at the northwest it is interrupted by a crater chain. Also shown in the sketch is a low ridge running southeast to a hill, and to the south of this ridge is a distinct crater from which a three-crater row points toward the ridge. From the crater there is either a narrow valley or a cleft extending southeastward, parallel to the ridge.

STRATHMORE R. B. COOKE
School of Mines and Metallurgy
University of Minnesota
Minneapolis 14, Minn.

LYING in the eastern part of Mare Tranquillitatis is the ring-plain Arago, some 16 miles in diameter. Its interior contains various minor irregularities, including several terraces on the inner walls and a slight central hill which is connected to the north wall by a low ridge. The crater outline is decidedly irregular, with a landslip on the east wall.

The ramparts are only about 5,800 feet high on the west, but may be somewhat loftier on the east, where several small peaks cast pointed shadows at sunrise, two of them visible in the drawing. Curious spurs extend from the outer wall into the surrounding plain, one running southeastward almost as far as Manners. This spur has southward offshoots in the form of low ridges and a delicate rill, the latter apparently part of the extensive rill system paralleling the mare border.



The lunar crater Arago and its vicinity, drawn by Alika K. Herring as seen in his 12½-inch reflector, 375x, on March 4, 1960, at 3:45 Universal time. This was about six days after new moon, and as seen from Arago the sun was only 4.8 degrees above the horizon. The two large domes, below and to the right, are shadowless, proving that their flanks have very gentle slopes. South is at the top, and east is to the right.

West of Arago, the surface of Mare Tranquillitatis contains an intricate system of ridges and swells, well seen only under grazing illumination. They are prominent in the photograph on page 150 of the January, 1960, issue. While many of these ridges run more or less north and south, sharing with the nearby rills a concentricity with the mare edge, others are evidently the remnants of almost completely obliterated ancient rings. The largest of these ghost rings is approximately 50 miles across, and at one time may have been an imposing formation. These features vanish toward full moon, when the mare surface brightens and becomes laced with a complex tracery of diffuse light streaks and patches.

North and east of Arago are two well-known domes, for many years familiar objects to selenographers, and probably the first examples of their kind to be recognized. Under a low sun they are conspicuous even in very small telescopes as low, symmetrical swellings, but large instruments reveal their irregular shapes. This is clearly indicated by my drawing, made under favorable illumination and good seeing conditions.

During that observation, other irregularities were visible, including small peaks near the center of the northern dome

On April 30th, just north of Fargo, North Dakota, Dewey Bergquist took these auroral photographs, at 1:40 and 1:50 a.m. Central standard time, respectively. The 10-second exposures were obtained with an f/4.5 lens.

and northwest of the midpoint of the eastern one. But I could not detect summit craterlets on either dome, and it seems certain that they do not exist, since nearby small craterlets of the expected size were easily visible.

Arago is a member of a long irregular chain of craters that extends from Sabine on the south to Maraldi on the north. Like the ridges and clefts, this chain is approximately concentric with the northern and eastern edges of Mare Tranquillitatis. In my opinion, the agreement is not accidental, but has resulted from the diastrophic forces that shaped the lunar surface.

ALIKA K. HERRING
1312 Arlington Ave.
Anaheim, Calif.

CALIFORNIA LUNAR PROJECT

Members of the San Fernando Valley Astronomical Society are now using their telescopes to obtain lunar photographs that are to be combined into a photographic atlas of our satellite. To be included in the atlas are detail drawings of some features of particular interest.

Much of this work is being done with 10-inch reflectors. In the last year, nearly 80 pictures have been taken, and enlarged to a standard size of seven by five inches.

Another club project was co-operative observing of Mars during its 1958 apparition. The results of this program were combined into a map of the Martian surface, which we displayed at the 1959 Nationwide Amateur Astronomers Convention in Denver.

KENT DE GROFF
12150 Hartsook St.
N. Hollywood, Calif.

CORRECTION

On page 471 of last month's issue, in line four of the first column, read "horizontal" instead of "vertical."

SPRINGTIME AURORAS

No less than six different displays of northern lights were witnessed by widely scattered amateurs during the final week of April and the first week in May. The most intense was that seen on April 27-28, being predominantly green in color.

At Buffalo, New York, Clark Chapman noted that the aurora impressed him strongly as a vast storm, rather than merely a beautiful display. At its climax, great waves of light were traveling from the horizon to a spot south of the zenith. This flaming aurora presented no color, whereas the earlier homogeneous and rayed arcs had been green.

Also in April, there were displays on the 28-29 and 29-30. The three auroras of early May were observed on the 3-4, 4-5, and 6-7.

In this view of M23, taken from a Palomar 48-inch Schmidt photograph, the cluster nearly fills the 40-minute-wide area of the sky shown here. South is toward the top.

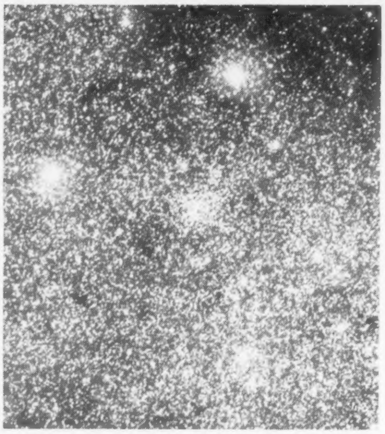
DEEP-SKY WONDERS

CHARLES MESSIER, in view of his modest equipment, must have been a talented and careful observer. He recorded many objects that an amateur of today might easily pass over. This is especially true of the region of Sagittarius, which is crowded with starclouds and dark nebulae. Here, just above the "milk dipper," lie two interesting galactic clusters. Neither is mentioned in Webb's or Smyth's guides, possibly because of their southerly declinations.

M23 (NGC 6494) is at right ascension $17^h\ 54^m.0$, declination $-19°\ 01'$ (1950 coordinates). It is seen against a rather dark background for this part of the Milky Way, and thus it stands out strongly. Two-power sport glasses reveal its nature and show a 6th-magnitude star on its edge, giving rise to a "diamond ring" effect. A 20 x 120 Moonwatch telescope makes M23 a marvelous object, and will also show traces of the dark nebulosities that abound in this region – B84a in the Barnard atlas is just perceptible.

In a 10-inch telescope, M23 fills over half the field of a low-power ocular (the cluster is $25'$ in diameter). Many of the 120 stars in this grouping appear to be arranged in curved lines, and Barnard compares this cluster with the globular M13 in Hercules. To me, however, the "curves" in M13 are much more striking than those in M23. The best current estimates place this cluster at a distance of about 2,000 light-years, relatively near to us.

Slightly east of M23 is M24 (NGC 6603), at $18^h\ 15^m.5$, $-18°\ 27'$. Though of magnitude 5 – about two magnitudes brighter than M23 – it is only $4'$ in diameter. Lying on a great starcloud, binoculars show it as merely a brightish star. Even the Moonwatch apogee telescope just hints at its true nature, and at least a 10-inch is required to prove adequately that it is a big galactic cluster. While the number of stars listed is 50, a 36-inch suggests that there are about 100.



The compact cluster M24 is centered in this field, 40 minutes of arc wide, taken from a photograph by the Palomar 48-inch Schmidt telescope. South is upward, east to the right, as in an inverting telescope.

Many amateurs do not know this object. Indeed, one must look sharply at the picture in Barnard's atlas to see that it is not a star, and it is not even marked on his key map for the region. The dark nebulae surrounding this starcloud are particularly interesting. The 20 x 120 shows both B92 and B93, while a 6-inch rich-field reflector does a bit better. Amateurs who own such equipment should reserve some especially clear nights for these dark objects.

WALTER SCOTT HOUSTON
Rte. 3, Manhattan, Kans.

SUNSPOT NUMBERS

The following American sunspot numbers for April have been derived by Dr. Sarah J. Hill, Whitin Observatory, Wellesley College, from AAVSO Solar Division observations.

April 1, 109; **2,** 132; **3,** 160; **4,** 161; **5,** 177; **6,** 112; **7,** 117; **8,** 109; **9,** 96; **10,** 103; **11,** 132; **12,** 126; **13,** 134; **14,** 115; **15,** 130; **16,** 111; **17,** 110; **18,** 98; **19,** 109; **20,** 101; **21,** 98; **22,** 94; **23,** 94; **24,** 102; **25,** 86; **26,** 89; **27,** 71; **28,** 83; **29,** 89; **30,** 78. Mean for April, 110.9.

Below are provisional mean relative sunspot numbers for May by Dr. M. Waldmeier, director of Zurich Observatory, from observations there and at its stations at Locarno and Arosa.

May 1, 97; **2,** 97; **3,** 102; **4,** 96; **5,** 87; **6,** 93; **7,** 133; **8,** 143; **9,** 142; **10,** 149; **11,** 147; **12,** 127; **13,** 135; **14,** 105; **15,** 85; **16,** 101; **17,** 114; **18,** 106; **19,** 108; **20,** 115; **21,** 100; **22,** 112; **23,** 125; **24,** 147; **25,** 148; **26,** 130; **27,** 148; **28,** 142; **29,** 158; **30,** 121; **31,** 111. Mean for May, 119.5.

BOOKS AND THE SKY

PHOTOGRAPHIC LUNAR ATLAS

G. P. Kuiper, editor. University of Chicago Press, Chicago, Ill., 1960. 230 sheets, boxed. $30.00.

WITH increasing interest in the moon, the publication of a magnificent atlas of the lunar surface, by G. P. Kuiper with the aid of D. W. G. Arthur, E. Moore, J. W. Tapscott, and E. A. Whitaker, is an event of much importance. Monumental is the word for its form as well as its significance, for the atlas is a big carton containing nearly 20 pounds of large-scale photographs, taken with some of the world's greatest telescopes.

We may sort out the many existing maps and atlases of the moon into two kinds, according to their uses. In the first class belong charts for identification of the more prominent craters, mountains, and seas. The outstanding work of this class is M. A. Blagg and K. Müller's *Named Lunar Formations,* issued in 1935 by the International Astronomical Union. Its two volumes — an atlas and catalogue — furnish the official nomenclature for some 6,000 formations. Unfortunately, the atlas has recently gone out of print, and a new edition by the IAU would be most desirable.

For the amateur, there are a number of easily obtainable charts identifying several hundred major lunar formations. Among the best of these is K. Andel's *Mappa Selenographica* (1926), inexpensively reissued as the lunar map of Sky Publishing Corp. Mention should be made of the very serviceable map of the moon available free from the Missile and Space Vehicle Department, General Electric Co., 3198 Chestnut St., Philadelphia 4, Pa.

The second kind of lunar atlas is a detailed depiction of the surface, intended for the scientific study of the moon's formations and their interrelations. The 19th-century comprehensive charts by W. Lohrmann, W. Beer and J. H. Mädler, E. Neison, and J. F. J. Schmidt, which represent the moon as seen in 4- to 6-inch refractors, are mostly of historical interest today. W. Goodacre continued the same tradition, while H. P. Wilkins' 200-inch map (1930) and his 300-inch map (1946) present an enormous amount of detail, some visible only in very large telescopes.

As materials for further research, large visually prepared maps have serious drawbacks. In many parts of the moon, the richness of detail is too overwhelming for more than summary treatment. To complete some of these immense undertakings, cartographic standards were inevitably lowered, with loss in accuracy and homogeneity.

A fundamental weakness of any nonphotographic lunar atlas is that all the information in it has had to filter through the brain and hand of its author, and therefore it suffers from any limitation of his outlook. For example, domes, banded craters, and the lunar grid system first attracted much attention only in fairly recent years. Therefore, a systematic study of them using older atlases would lead to little. In some cases, too, the cartographer may not have attached importance to quantitative or statistical problems.

As early as the 1890's, successful experiments in lunar photography with large telescopes at Lick and Paris observatories stimulated the production of a number of photographic atlases of our satellite. The best of these was the *Atlas Photographique de la Lune,* compiled by M. Loewy and P. Puiseux at Paris between 1896 and 1910. Of somewhat lower quality were the albums by L. Weinek of Prague (1901) and W. H. Pickering of Harvard (1903). However, during the next half century, great improvements were made in telescopes, photographic materials, and methods of reproduction, and at several observatories moon negatives of exquisite quality continued to be taken.

In 1955, Dr. Kuiper, then of Yerkes and McDonald Observatories, formed the plan of compiling a new photographic atlas from the best existing plates of the moon taken with the 100-inch Mount Wilson reflector, 36-inch Lick refractor, 40-inch Yerkes telescope, and 24-inch Pic du Midi refractor. These were supplemented by new photographs with the 82-inch McDonald reflector and from Yerkes Observatory.

The very extensive labor of selecting and preparing the photographs for publication took Dr. Kuiper and his collaborators over four years. Their *Photographic Lunar Atlas* consists of a total of 281 pictures. Of these 212 form the main body of the atlas, each of 44 different regions being shown on the average under five different conditions of solar illumination. In addition there are 63 supplementary photographs, mainly of limb regions, and key charts on which about 700 surface features are marked.

Important advantages result from the various regions being shown under several illuminations: sunrise, sunset, and high sun. For study of low relief, grazing illumination is necessary, but rays and bright spots require a higher sun.

In this atlas, the scale is 100 inches to the lunar diameter, or 1:1,370,000. Thus one inch, at the center of the lunar disk, corresponds to 21.6 miles. According to Dr. Kuiper, the best of the photographs have a resolution of 0.4 second of arc, or half a mile. Hence the scale of the atlas is sufficient to show all the detail it contains without the use of a magnifying glass.

The charts are 16 by 20 inches, printed so that four are on a folded sheet that opens out to 64 by 80 inches. In the main atlas,

all the pictures of the same part of the moon are on one sheet. Thanks to a convenient thumb-tab arrangement, the desired sheet can at once be selected from the large hinged box containing the atlas.

The charts are printed by photo-offset on paper that will take pencil, ink, or crayon. To preserve details both in the highlights and in the much fainter terminator regions, photographic dodging was used on most of the paper prints from which the atlas was reproduced. In general, this process was highly successful, but occasional charts have exaggerated or inadequate contrast. Certain of the photographs have excessive graininess.

Accompanying the *Photographic Lunar Atlas* is a 23-page booklet, containing a detailed explanation of its construction. There are also tables identifying the original of each picture, providing the date, time, colongitude, and libration. Unfortunately, the corresponding selenographic latitudes of the sun are not tabulated, although they are needed for calculating the sun's altitude above any point on the moon.

The booklet provides an alphabetical index of about 700 lunar features, facilitating their identification in the atlas. The nomenclature is that of the IAU, but in about 40 cases the spelling or the orthography of the IAU have been corrected. These changes are of unequal merit, though based on careful study. To nearly all selenographers, crater names are arbitrary labels, as Arabic star names are. Revisions to amend misspellings made two centuries ago, but consistently adhered to by later astronomers, may cause needless confusion. The majority of the changes, however, are improvements.

Even a quick examination of the *Photographic Lunar Atlas* will show the remarkable success Dr. Kuiper and his co-workers have had in making generally available the details in the world's finest moon photographs. Take, for example, chart C3-b, showing the eastern part of Mare Serenitatis near sunset, from a 100-inch Mount Wilson plate. Inside the Linné bright spot, the tiny central craterlet, only about 900 meters in diameter, is distinctly seen with its interior shadow.

Another test that many experienced lunar observers will apply is the detail on the floor of the crater Plato. On sheet D2-a, it is easy to pick out five of its interior craterlets. Another elusive object, well shown on F3-a, is the remarkable serpentine cleft running northward from Marius.

The availability of this excellent atlas offers many opportunities for useful lunar work by both professional and amateur astronomers. Consider, for instance, lunar domes. The literature of this subject is in confusion; no adequate list of domes has been published, and the problem of classifying them has scarcely been touched. Domes are quite easy to pick out here, and it should be a straightforward task to make a complete listing of those the atlas contains, with their positions, diameters, and descriptions. A systematic dome catalogue of this sort would be a valuable contribution.

Another suggestion involves the determination from shadow lengths of the depths of craters and the heights of lunar mountains. Because of the generous scale of the atlas, these shadows can be measured with a millimeter rule. The time when each photograph was taken is given, and the selenographic co-ordinates of the point casting the shadow are obtainable from the IAU atlas, for example. Then the height can be calculated, using

Perfect companions for your observing programs

DE LUXE ATLAS OF THE HEAVENS and the ATLAS COELI CATALOGUE

Both by Antonin Becvar and his coworkers at the Skalnate Pleso Observatory

The **De Luxe Atlas of the Heavens** has 16 sturdily bound charts, which cover the entire sky to magnitude 7.75. Printed in many colors, more than 35,000 celestial objects, including over 100 radio sources, are plotted on the large 16½-by-23-inch maps. You'll find double, multiple, and variable stars; novae, clusters, globulars, and planetaries; bright and dark nebulae; the Milky Way and constellation boundaries. Bayer-letter and Flamsteed-number designations are given. The transparent grid overlay facilitates locating the object under study. An atlas without equal!

The **Atlas Coeli Catalogue** (*Atlas Coeli — II, Katalog 1950.0*) is the most complete check list of celestial objects ever offered the amateur observer. Listed, with descriptive data, are the 6,362 stars brighter than magnitude 6.26, with their right ascensions and declinations for 1950, precessions, proper motions, magnitudes, and spectra; 293 open star clusters; 100 globular clusters; 240 bright diffuse nebulae; 144 planetaries; 1,131 galaxies; some 1,750 visual double and multiple stars; and 633 variables bright enough for amateur observing. Sturdily cloth bound, this 367-page book is 8¼ by 11¾ inches in size. Explanations in English.

De Luxe Atlas of the Heavens **$9.75**

Atlas Coeli Catalogue **$8.75**

SPECIAL: Both of these items **$17.50**

— OTHER ATLASES —

FIELD EDITION ATLAS OF THE HEAVENS. Each chart is reduced from the original Atlas Coeli and is printed on heavy, stiff paper 18 by 12¼ inches. Stars are white on black background. The 16 charts are unbound. Perfect for outdoor use. **$4.00 each; 2 for $7.50**

NORTON'S STAR ATLAS. This famous star atlas and reference handbook covers the whole heavens, showing over 9,000 objects: stars to magnitude 6⅓, nebulae, and clusters. Descriptive lists of 500 interesting subjects for viewing with small telescopes, and useful data for observing the sun, moon, and planets. New 14th edition, 1959. 8½ by 11 inches. 108 pages. **$5.25**

POPULAR STAR ATLAS. A simpler version of Norton's *Star Atlas*, the 16 bound maps show all stars down to magnitude 5½. 7½ by 9½ inches. 38 pages. **$2.00**

ATLAS ECLIPTICALIS 1950.0. A bound set of 32 charts, each 17½ by 24 inches, covers declinations between +30° and −30°, complete to magnitude 9.0, scale two centimeters per degree, epoch 1950.0. (Place your order with us and allow time for its transmission to the publisher in Czechoslovakia, from whom the atlas will be shipped directly to you — in about six to ten weeks.) **$17.00**

PHOTOGRAPHIC LUNAR ATLAS. Expertly assembled under the direction of Gerard P. Kuiper, this atlas contains 281 of the finest photographs of the moon in existence, taken with large telescopes at Mount Wilson, Lick, Pic du Midi, McDonald, and Yerkes observatories. The 230 sheets measure 15½ by 19 inches, gathered looseleaf in a sturdy box, and are thumb-indexed and numbered to permit easy location of strips of the moon's surface. This magnificent atlas is indispensable to every professional and amateur astronomer seriously interested in lunar problems. **$30.00**

— BOOKS FOR THE AMATEUR —

LAROUSSE ENCYCLOPEDIA OF ASTRONOMY. By Lucien Rudaux and G. de Vaucouleurs. "By far the best general survey of its kind for anyone who has graduated from the ordinary popularizations and wants a taste of the real business of astronomy. . . . The lucid and interesting text is supported by a most effective and intelligently planned collection of diagrams, photographs, and charts. . . . This is an achievement of a high order." — **Scientific American**. Many full-color renditions. Full-page size is 8 by 11⅛ inches. 506 pages, 818 illustrations. **$12.50**

THE HISTORY OF THE TELESCOPE. By Henry C. King. A complete account of the development of the telescope from the crude instruments of the ancients to the giants of today. "An inspiring story of human progress. . . ." 7½ by 10 inches, 456 pages, 196 illustrations. **$7.50**

MAKING YOUR OWN TELESCOPE. By Allyn J. Thompson. Join the tens of thousands of amateurs who are using this basic book on telescope making. Complete step-by-step directions for making and mounting your own 6-inch reflecting telescope at low cost. In easy-to-understand chapters, you learn how to grind, polish, and figure the mirror, and how to make an equatorial mount that will provide a sturdy, solid support for your mirror. 211 pages, 104 illustrations (6th printing). **$4.00**

PHILIP'S PLANISPHERE

The latest edition of this world-famous star finder, suitable for use within 10 degrees of latitude 42° north. Beautifully printed in dark blue and gold, it identifies the principal constellations and stars above the observer's horizon for any time of the night throughout the year. It is set quickly by turning the transparent plastic overlay around its central pivot, which is at the pole of the star chart on the substantial cardboard base plate. Directions for using the device are given in four languages. **$3.00**

STELLAR FACTS AT A GLANCE

COLOR MAP OF THE NORTHERN HEAVENS

With this beautiful wall chart you rarely need to "crack a book" to find quickly how far away that 1st-magnitude star is, its spectral type, absolute luminosity, or other pertinent facts. Such important star groupings as Gould's belt, the Scorpius-Centaurus association, the blue stars of Orion, are all indicated by the star symbols, colored vividly to show spectral class. The northern sky to −45° is shown on a polar projection; stars brighter than magnitude 5.1 included. Printed on an attractive sky-blue background, the chart is a huge 30 by 34½ inches and is mailed unfolded in a heavy tube. Now only **$1.00**

— OTHER MAPS AND CHARTS —

COLOR CHARTS OF THE MOON. Two striking renderings of the first- and last-quarter moon. Each lunar half is an impressive 27 inches in diameter; the over-all size of the chart is 23 inches wide by 33 inches high. Printed in predominantly gold and black on heavy paper. Charts mailed unfolded. **$2.00 per set of 2**

ELGER'S MAP OF THE MOON. The moon chart itself is 18 inches high by 17½ inches wide and identifies all the important lunar features. Below the map are notes by H. P. Wilkins on 146 of the more interesting regions. Mailed unfolded. **$3.00**

LUNAR MAP. In two colors and over 10 inches in diameter, the map identifies the most important features on the moon, including 326 mountains, seas, and craters. Handy finding list on reverse side. **25c each; 3 or more, 20c each**

— CELESTIAL PHOTOGRAPHS —

SPLENDORS OF THE SKY. A 36-page large picture booklet, with short and easy-to-understand captions. Among the many full-page illustrations, taken with the giant telescopes of Mount Wilson and Palomar Observatories and Lick Observatory, are a close-up view of the moon's surface, and a field of distant galaxies. 36 pages, 66 illustrations, paper bound. Now only **50c**

MOON SETS. 18 pictures of the entire visible face of the moon, made from unsurpassed Lick Observatory negatives of the first and last quarters. Each print 8½ by 11¾ inches. Key charts supplied. **$3.00 per set**

LUNAR CRESCENT SETS. 10 Lick Observatory pictures that form a matching series to Moon Sets, but for the waxing crescent 4½ days after new moon, and the waning crescent about five days before new moon. **$2.50 per set**

SKY SETS I. 24 pictures of objects in the solar system and in the Milky Way, all celestial wonders of interest and beauty. Each print 8½ by 11¾ inches. **$4.00 per set**

SKY SETS II. 24 pictures of nebulae in our galaxy, portraits of other galaxies, many made with the 200-inch telescope, and four drawings of the 200-inch telescope by Russell W. Porter. Each print 8½ by 11¾ inches. **$4.00 per set**

— OTHER SKY PUBLICATIONS —

SOUTHERN HEMISPHERE CONSTELLATIONS. By Sir William Peck. 12 star maps for latitude 40° south. **$2.50**

RELATIVITY AND ITS ASTRONOMICAL IMPLICATIONS. By Dr. Philipp Frank. **75c**

HOW TO BUILD A QUARTZ MONOCHROMATOR for Observing Prominences on the Sun. By Richard B. Dunn. **50c**

THE STORY OF COSMIC RAYS. By Dr. W. F. G. Swann. **75c**

Write for free descriptive catalogue. All items sent postpaid. Please enclose your check or money order.

SKY PUBLISHING CORPORATION Harvard Observatory, Cambridge 38, Massachusetts

an appropriate modification of the formulae given by T. L. MacDonald in the *Journal* of the British Astronomical Association, *41*, 367, 1931.

The Kuiper atlas will also be of great value to the amateur who has a more traditional program of making detail drawings of craters from visual observations. With its aid, he can prepare beforehand an outline of the region, thus obtaining a much more accurate scale and orientation for his drawing. The atlas will also serve as a referee in many cases for the confirmation or disproof of visual findings with moderate-sized or small telescopes.

With very large telescopes and fine seeing, visual observations have a resolution of about 0.1 second, or four times better than the best photographs. Thus the Kuiper atlas is very suitable as a base for plotting minute detail, during visual work with great telescopes.

Without question, the *Photographic Lunar Atlas* is the most important single contribution to selenography in many years. Its price is moderate, considering the wealth of information it contains. For anyone seriously interested in the moon, this beautiful work is a necessity.

J. A.

HANDBOOK FOR SPACE TRAVELERS

Walter B. Hendrickson, Jr. Bobbs-Merrill Co., Inc., Indianapolis, Ind., 1959. 256 pages. $3.95.

THE TITLE of this book promises something far more pretentious than its contents deliver. What is to be a banquet turns out a smorgasbord — a smattering of everything and not much of anything.

The author has produced a readable, diverting book written apparently for intermediate grade school or junior high school students. It will prepare no one for real space travel nor will serious students have time for it, but it may be worth a couple of hours in an armchair by a newspaper reader who doesn't want to go too far.

The book is divided into four sections: Tools for Space Exploration, History of Rockets, Rocket Bases, and Future of Rockets and Where to Go in Space. These subjects are dealt with in 35 chapters in a total of only about 250 pages. As a result, extensive territory is covered in so few pages that there is not enough information to develop any sound concepts or principles. For example, there are 19 sentences about radio astronomy, which tell so little they might better have been omitted. The impression is left that radio waves from space are due to galaxies in collision, a far too limited conclusion even though true for some cosmic radio sources.

Furthermore, the author uses too positive an approach to such developments

as man in space, space stations, rocket ships, and trips into space. He writes as though these were all so advanced that every detail had been worked out and only the realization remains. The scientific method requires that conclusions come only after there are ample data to support them.

In an effort to be readable, the author takes too much journalistic license. As a result, current plans and speculations – which may well become reality – assume a science-fiction tone through the certainty with which they are presented. This quality makes it impossible to recommend the book for any serious study, though it may serve as entertainment.

The final 10 chapters on astronomical bodies in space are somewhat better. There is more logic to the organization, and the selection of material holds up rather well. Factual data provide a quick view of basic astronomy without pretending to go into depth.

Some statements would be questioned by astronomers; the author apparently did not have access to up-to-date information. For instance, he does not give the latest temperature data for Venus, and he uses 750,000 light-years as the distance to the Andromeda galaxy although this has twice been revised upward in the past eight years.

JOHN STERNIG
Glencoe Public Schools
Glencoe, Ill.

NEW BOOKS RECEIVED

RADIOASTRONOMIE, *J. L. Steinberg* and *J. Lequeux*, 1960, *Dunod*, 92 Rue Bonaparte, Paris 6, France. 294 pages. 19 NF, paper bound.

Two French scientists present a survey of radio astronomy, covering principles, instruments, and findings from observations of the sun, planets, the galaxy, and discrete sources. The largely descriptive French text is well illustrated, having 156 pictures and diagrams, but it lacks an index.

A BEGINNER'S GUIDE TO THE SKIES, *R. Newton Mayall* and *Margaret W. Mayall*, 1960, *Putnam's*. 184 pages. $2.50.

Simple charts and brief descriptions of the constellations visible from the United States are provided for the beginning amateur who observes with the naked eye or binoculars. For each constellation are listed several interesting objects, such as bright star clusters, wide doubles, and red or variable stars.

THE SEARCH FOR ORDER, *Cecil J. Schneer*, 1960, *Harper*. 398 pages. $6.00.

Writing for the informed general reader, Cecil J. Schneer traces the development of some fundamental scientific ideas from the astronomy of the ancient Greeks to the physics of the present day.

PHYSICAL SCIENCE, *Donald S. Allen* and *Richard J. Ordway*, 1960, *Van Nostrand*. 825 pages. $8.25.

This college textbook is intended to provide for students with nonscience majors a broad view of the physical sciences, by surveying selected elementary topics in physics, astronomy, meteorology, and geology.

VISTAS IN ASTRONOMY, Vol. 3, *Arthur Beer*, editor, 1960, *Pergamon*. 345 pages. $18.00.

Originally conceived as only a two-volume survey, *Vistas in Astronomy* is to be continued as a permanent series. Vol. 3 has 21 chapters, dealing with stellar dynamics, geophysics, instruments, the solar system, stellar astronomy and evolution, photometry, spectroscopy, cosmology, and galaxies.

THE OTHER SIDE OF THE MOON, *U.S.S.R. Academy of Sciences*, 1960, *Pergamon*. 36 pages. $2.50.

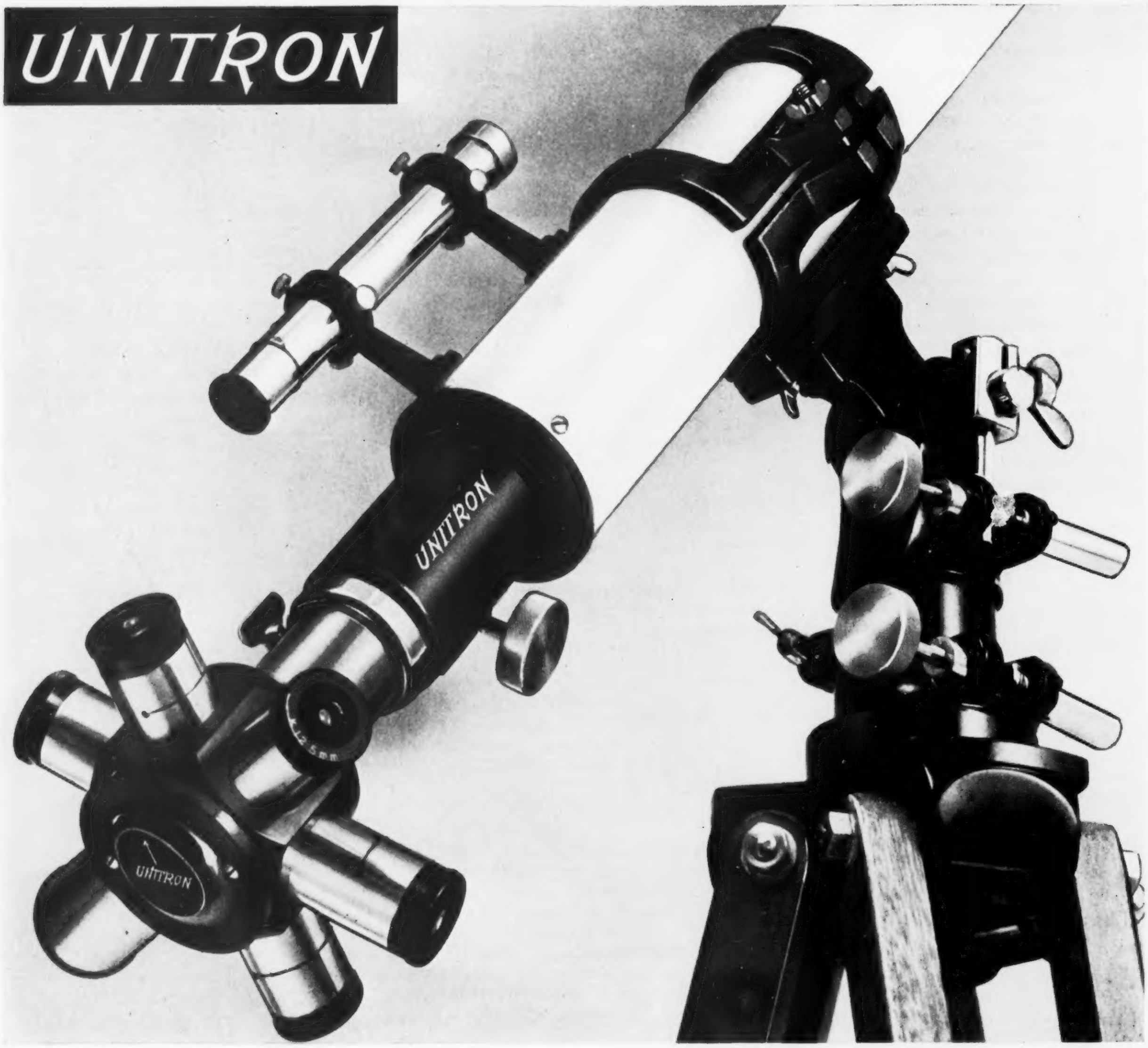
Translated from the Russian by J. B. Sykes, this is a brief account of the Soviet rocket launched on October 4, 1959, that photographed the far side of the moon. Three of these pictures are reproduced, but less than one page is devoted to a description of the hitherto unseen part of the moon.

STARBOUND, *Eileen* and *Raymond Schussler*, 1960, *Putnam's*. 160 pages. $2.95.

This simplified account of rocketry and space travel is intended for younger readers.

THREE COPERNICAN TREATISES, *Edward Rosen*, editor, 1959, *Dover*. 283 pages. $1.75, paper bound.

Translations into English are given here for the *Little Commentary* and *Letter Against Werner* by Nicholas Copernicus (1473-1543), and for the *Narratio Prima* by his friend George Rheticus (1514-76). These three treatises are important source material on Copernicus' revolutionary ideas in astronomy. In this revised edition of his 1939 work, Edward Rosen has provided an extensively annotated bibliography of 877 articles and books published on Copernicus between 1939 and 1958.



It takes only $12.50 down to own this UNITRON

Little wonder that the UNITRON 2.4" Altazimuth Refractor has long been America's most popular low-priced refractor.

For UNITRON and only UNITRON combines unexcelled optical and mechanical performance with exclusive features designed to increase your observing pleasure. As an example, take UNIHEX — the Rotary Eyepiece Selector which relieves you of the burden of fumbling with eyepieces in the dark. Or, perhaps your observing situation may call for the DUETRON Double Eyepiece, the erecting prism system, the Astro-camera 220, or the sun screen.

Optically speaking, UNITRON Refractors duplicate the performance of larger telescopes of other types. Furthermore, there are no mirror surfaces to become tarnished, no secondary optics to cause diffraction patterns, and no folding of the light back on itself with consequent loss of definition. It is not surprising that you see more and see better with a UNITRON.

The UNITRON 2.4" Altazimuth Refractor is priced at only $125 complete with tripod, sturdy mounting with micrometric slow-motion controls, four eyepieces, carrying case, and accessories. Using our Easy Payment Plan, a mere 10% down payment of only $12.50 brings this UNITRON to you.

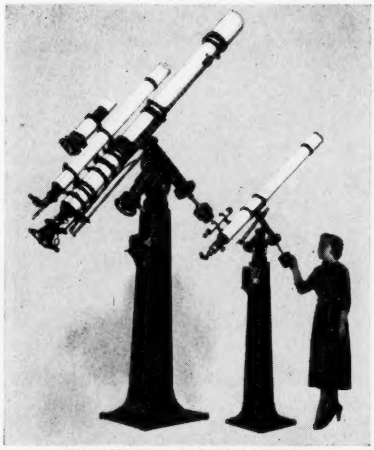
With interest in astronomy at an all-time high, now is the time to treat yourself to a UNITRON. After all, you deserve the very best.

See the back cover.

UNITRON INSTRUMENT DIVISION of UNITED SCIENTIFIC CO.
204-206 MILK STREET BOSTON 9, MASSACHUSETTS

Choose UNITRON for optical and mechanical excellence

UNITRON 6" AND 4" MODELS



UNITRON 6" and 4" Model 166V.

There are UNITRON 6" models priced from $5125 to $6075. Write for Bulletin 600.

HOW TO ORDER A UNITRON

Send check or money order in full or use our Easy Payment Plan, as described below. Shipments made express collect. Send 20% deposit for C.O.D. shipment. UNITRON instruments are fully guaranteed for quality, workmanship, and performance, and must meet with your approval or your money back.

Use Our EASY PAYMENT PLAN

UNITRON's popular Easy Payment Plan is a convenient and economical way to buy your UNITRON Refractor when you do not want to disturb your savings or when you haven't the total cost of the telescope immediately available. The down payment required is 10%. The balance due is payable over a 12-month period, and there is a 6% carrying charge on the unpaid balance. Your first payment is not due until 30 days after you receive the instrument, and if you should want to pay the entire balance due at that time, the carrying charge is canceled. (6" models available on special plan.)

To the newcomer and more experienced astronomer alike, the choice of "the best" telescope is difficult and confusing . . . so many makes . . . so many models. An astronomical telescope must be designed to observe "point sources at infinity," and hence requires a precision optical system for crystal-clear definition. Optics and mountings must be equally precise to track the star or planet. One without the other is useless. Invest in a UNITRON and be certain of combined optical and mechanical excellence.

MANY Models To Choose From!

1.6" ALTAZIMUTH ($7.50 Down) — **$75**
with eyepieces for 78x, 56x, 39x

2.4" ALTAZIMUTH ($12.50 Down) — **$125**
with eyepieces for 100x, 72x, 50x, 35x

2.4" EQUATORIAL ($22.50 Down) — **$225**
with eyepieces for 129x, 100x, 72x, 50x, 35x

3" ALTAZIMUTH ($26.50 Down) — **$265**
with eyepieces for 171x, 131x, 96x, 67x, 48x

3" EQUATORIAL ($43.50 Down) — **$435**
with eyepieces for 200x, 131x, 96x, 67x, 48x

3" PHOTO-EQUATORIAL ($55.00 Down) — **$550**
with eyepieces for 200x, 171x, 131x, 96x, 67x, 48x

4" ALTAZIMUTH ($46.50 Down) with — **$465**
eyepieces for 250x, 214x, 167x, 120x, 83x, 60x

4" EQUATORIAL ($78.50 Down) with — **$785**
eyepieces for 250x, 214x, 167x, 120x, 83x, 60x, 38x

4" PHOTO-EQUATORIAL ($89.00 Down) with — **$890**
eyepieces for 250x, 214x, 167x, 120x, 83x, 60x, 38x

4" EQUATORIAL with clock drive — **$985**
($98.50 Down), Model 160V, eyepieces as above

4" EQUATORIAL with clock drive and metal — **$1075**
pier (**$107.50 Down**), Model 166V, eyepieces as above

4" PHOTO-EQUATORIAL with clock drive and — **$1175**
Astro-camera (**$117.50 Down**), with eyepieces
for 250x, 214x, 167x, 120x, 83x, 60x, 38x, 25x

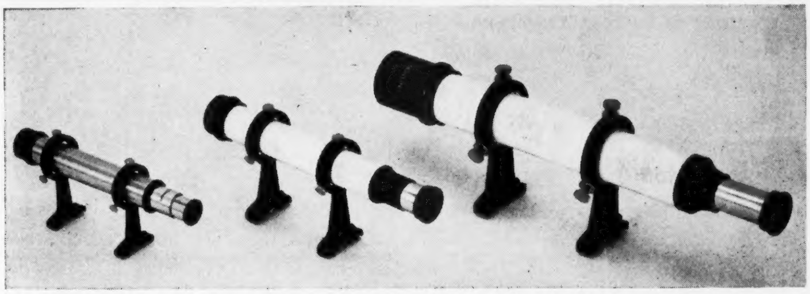
4" PHOTO-EQUATORIAL with clock drive, pier, — **$1280**
Astro-camera (**$128.00 Down**), with 10 eyepieces

Note These UNITRON Features

- LENSES are FULLY CORRECTED for spherical and chromatic aberration and are COATED for maximum brilliance and clarity of image. Optics especially designed for astronomical observation. AIR-SPACED OBJECTIVES.
- REFRACTOR type of design duplicates the performance of larger telescopes of other types. No mirrored surfaces to become oxidized. Superior definition to the very edge of the field.
- EYEPIECES of the HIGHEST QUALITY: Orthoscopic, Achromatized Symmetrical, Kellner, Huygens. Three to ten eyepieces included with each instrument.
- FINEST MATERIALS used throughout. DURALUMIN TUBE. Moving parts of BRASS carefully machined to close tolerances, and finished in CHROMIUM. No surplus components used.
- MODERN DESIGN based on time-tested engineering principles. HANDSOME APPEARANCE to which no illustration can do justice.
- EQUATORIAL MODELS have slow-motion controls for **both** declination and right ascension as well as convenient clamps on both axes. Sturdy TRIPOD (or PIER).
- ALTAZIMUTH MODELS have slow-motion controls for **both** altitude and azimuth as well as clamps for both co-ordinates. Sturdy TRIPOD.
- VIEW FINDER with crosshair eyepiece.
- RACK-AND-PINION FOCUSING.
- Choice of UNIHEX Rotary Eyepiece Selector or STAR DIAGONAL and ERECTING PRISM for TERRESTRIAL OBSERVATION. The same complete range of terrestrial magnifications as for celestial observation.
- SUNGLASS for solar observation.
- ADDITIONAL ACCESSORIES available to add further to your observing pleasure.

Higher- and lower-power eyepieces available for all models. Prices include basic accessories, tripod and mounting, fitted wooden cabinets, and operating instructions.

New UNITRON View Finders



UNITRON's popular view finders with newly designed optics and mechanical features are better than ever. From left to right: 23.5 mm., 30 mm., 42 mm.

1. **VIEW FINDER** (Used on UNITRON 2.4" Equatorials): 23.5-mm. (.93") achromatic objective, 6x eyepiece with crosshairs. Chromed brass tube. Mounting brackets with centering screws.
Only $8.50 postpaid

2. **VIEW FINDER** (As used on UNITRON 3" Refractors): 30-mm. (1.2") coated achromatic objective and 8x eyepiece with crosshairs. Other details as in View Finder 3.
Only $10.75 postpaid

3. **VIEW FINDER** (As used on UNITRON 4" Refractors): 42-mm. (1.6") coated achromatic air-spaced objective. 10x eyepiece with crosshairs. Duralumin tube finished in white enamel. Dewcap. Furnished with mounting brackets, centering screws for collimation, and mounting screws. This finder measures approximately 16" overall. It is light in weight, compact and small enough for use as a hand telescope furnishing spectacular wide-field views of the sky.
Only $18.00 postpaid

UNITRON INSTRUMENT DIVISION OF UNITED SCIENTIFIC COMPANY
204-206 MILK STREET · BOSTON 9, MASSACHUSETTS

Get UNITRON's FREE Observer's Guide and Catalog on ASTRONOMICAL TELESCOPES

This valuable 38-page book is yours for the asking!

With artificial satellites already launched and space travel almost a reality, astronomy has become today's fastest growing hobby. Exploring the skies with a telescope is a relaxing diversion for father and son alike. UNITRON's handbook contains full-page illustrated articles on astronomy, observing, telescopes and accessories. It is of interest to both beginners and advanced amateurs.

Contents include—

- **Observing the sun, moon, planets and wonders of the sky**
- **Constellation map**
- **Hints for observers**
- **Glossary of telescope terms**
- **How to choose a telescope**
- **Amateur clubs and research programs**

UNITRON
INSTRUMENT DIVISION of UNITED SCIENTIFIC CO.
204-206 MILK STREET · BOSTON 9, MASS.

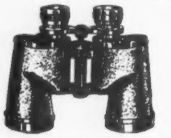
Please rush to me, free of charge, UNITRON's new Observer's Guide and Telescope Catalog 20-D.
Name ____________________
Street ____________________
City ______________ State ________

OPTICS

Coated Binoculars

Beautifully styled imported binoculars. Precision made.

LOW, LOW PRICES!



American Type

"Zeiss" Type

Complete with carrying case and straps. American type offers a superior one-piece frame and clean design. Individual Focus (IF) or popular Center Focus (CF).

Cat. No.	Size	Field at 1,000 yards	Type	Price, ppd.
S1149	6 x 15 IF	360 ft.	Opera	$12.75
S1436	6 x 30 CF	395	"Zeiss"	18.75
S1435	6 x 30 IF	395	"Zeiss"	16.75
S1438	7 x 35 CF	341	"Zeiss"	20.75
S1437	7 x 35 IF	341	"Zeiss"	17.95
S1771	7 x 35 CF	341	American	23.50
S1439	7 x 35 CF	578	American*	35.00
S2191	7 x 50 CF	530	American**	42.50
S1106	7 x 50 CF	372	"Zeiss"	24.95
S-961	7 x 50 IF	372	"Zeiss"	22.50
S1503	7 x 50 CF	372	American	32.50
S1443	8 x 30 CF	393	"Zeiss"	21.00
S1229	8 x 30 IF	393	"Zeiss"	18.25
S1108	10 x 50 IF	275	"Zeiss"	26.75
S1442	20 x 50 CF	183	"Zeiss"	33.75
S1441	20 x 50 IF	183	"Zeiss"	31.75

*Wide-angle 11° **Wide-angle

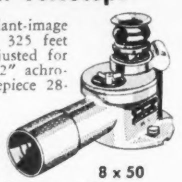
All prices above plus 10% Federal tax.

Monoculars

Brand new, coated optics, complete with pigskin case and neck straps.

Cat. No. S1576..........6 x 30..........$10.00 ppd.
Cat. No. S1577..........8 x 30.......... 11.25 ppd.
Cat. No. S1578..........7 x 35.......... 12.50 ppd.
Cat. No. S1303..........7 x 50.......... 14.75 ppd.
Cat. No. S1579.........16 x 50.......... 17.50 ppd.
Cat. No. S1580.........20 x 50.......... 20.00 ppd.

8-Power Elbow Telescope



8 x 50

This telescope has a brilliant-image 48° apparent field; actually 325 feet at 1,000 yards. Can be adjusted for focusing 15 feet to infinity. 2" achromatic objective, focusing eyepiece 28-mm. f.l., Amici erecting system. Turret-mounted filters: clear, red, amber, and neutral. Lamp housing to illuminate reticle for night use. Truly the biggest bargain you were ever offered. Original Gov't. cost $200.

Cat. No. S1686 Not Coated .... $13.50 ppd.
Cat. No. S1975 Coated .... $17.50 ppd.

Mirror Mounts

Cast aluminum, holds all of our mirrors with metal clips. Completely adjustable, assembled.

Cat. No. S1634 3-3/16" Mount for 4½" Tubing $4.00 ppd.
Cat. No. S1633 4¼" Mount for 5" Tubing . 4.00 ppd.
Cat. No. S1632 6" Mount for 7" Tubing . 6.50 ppd.

Prismatic Telescope

NEW!

80-mm. Objective

Big 80-mm.-diam. (3⅛") objective. Use for spotting or astronomical viewing. Great light-gathering power that will pick up faint objects even under poor sky conditions. Will show stars of the 11th magnitude — 100 times fainter than the faintest visible to the naked eye. Tripod included.

FIVE EYEPIECES

Power	Field at 1,000 yards	Exit pupil diam.	Relative Brightness
15x	122 ft.	5.4 mm.	29
20	122	4.0	16
30	61	2.7	7
40	49	2.0	4
60	32	1.3	1

Cat. No. S2052 .... $59.50 ppd.

60-mm.-diam. Scope. Same as above but with smaller objective. Equipped with same five eyepieces — 15x, 20x, 30x, 40x, 60x. With tripod.

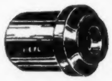
Cat. No. S1721 .... $42.95 ppd.

Astronomical Mirrors

These mirrors are of the highest quality. Aluminized and silicon-monoxide protective coating. You will be more than pleased with their performance.

Cat. No.		Diam.	F.L.	ppd.
S1429	Plate glass	3-3/16"	42"	$ 9.75
S1506	Pyrex	4¼"	45"	13.50
S1507	Pyrex	6"	60"	25.00
S2188	Pyrex	6" parabolic	48"	54.50

Mounted Eyepieces



The buy of a lifetime at a great saving. Perfect war-surplus lenses set in black-anodized standard aluminum 1¼" O.D. mounts.

Cat. No.	F.L.	Type	ppd.
S2192	6 mm. (¼")	Orthoscopic	$13.25
S1851	6 mm. (¼")	Ramsden	4.75
S1853	12.5 mm. (½")	Ramsden	4.50
S1207	12.5 mm. (½")	Symmetrical	6.00
S1251	16 mm. (⅝")	Erfle (wide-angle)	12.50
S1257	16 mm. (⅝")	Orthoscopic	12.50
S1209	18 mm. (¾")	Symmetrical	6.00
S1211	22 mm. (27/32")	Kellner	6.00
S1835	27 mm. (1-1/16")	Kellner	4.50
S1355	32 mm. (1¼")	Plossl	12.50
S1253	35 mm. (1⅜")	Symmetrical	8.00
S1255	55 mm. (2-3/16")	Kellner	6.00
S1485	56 mm. (2¼")	Symmetrical	6.00

COATED LENSES 75 cents extra.

"Giant" Wide-Angle Eyepieces

Erfle eyepiece with 65° field, contains 3 coated achromats. 1½" E.F.L., clear aperture 2⅛". Has a focusing mount with diopter scale. Also makes an excellent 35-mm. Kodachrome viewer, magnifies seven times.

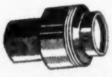
Cat. No. S1405 (Illustrated) ....$12.50 ppd.
Cat. No. S1858 Same as above without diopter scale .... 9.95 ppd.
Cat. No. S1595 1¼"-diam. ADAPTER for eyepieces above .... 3.95 ppd.

Wide-Angle Erfle

Brand-new eyepiece with 68° field; coated. E.F.L. 1¼". Focusing mount, 3 perfect achromats, 1-13/16" aperture.

Cat. No. S1020 ....$13.50 ppd.
Cat. No. S1593 1¼" diam. ADAPTER for eyepiece above .... 3.95 ppd.

An Economical Eyepiece



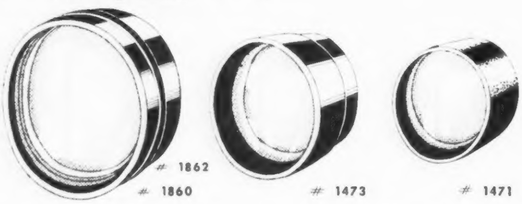
This mounted eyepiece has two magnesium-fluoride-coated achromatic lenses 29 mm. in diameter. Excellent definition. E.F.L. 1¼". Cell fits 1¼" tubing.

Cat. No. S1911 Coated ....$5.90 ppd.
Cat. No. S1991 Not Coated .... 5.25 ppd.

ASTRONOMICAL OBJECTIVES

• • • Air-spaced • • •

"THOSE WHO KNOW" BUY FROM US BECAUSE:



1862

1860

1473

1471

Each lens is thoroughly tested and guaranteed to resolve to Dawes' limit. They are corrected for the C and F lines (secondary chromatic aberration). The zonal spherical aberration and the chromatic variation of spherical aberration are negligible. The cells are machined to close tolerances so that they fit directly over or into our standard aluminum tubing, eliminating any mounting problems. Test a lens, or have any qualified person test it; we are certain that you will be satisfied. If not, take advantage of our money-back guarantee. *We offer the lowest-priced, hand-corrected, precision, American-made astronomical objective,* mounted in an aluminum cell. Our reputation for high-quality lenses has established us as the most reliable source in the industry.

HARD-COATED ON 4 SURFACES.

3¼" APERTURE f/15 — 48" F. L.	Cat. No. S1447	NOT COATED	$28.00 ppd.
	Cat. No. S1471	COATED	32.00 ppd.
4⅛" APERTURE f/15 — 62" F. L.	Cat. No. S1472	NOT COATED	$60.00 ppd.
	Cat. No. S1473	COATED	69.00 ppd.
6" APERTURE f/10 — 60" F. L.	Cat. No. S1861	UNMOUNTED	$150.00 ppd.
	Cat. No. S1860	MOUNTED	175.00 ppd.
6" APERTURE f/15 — 90" F. L.	Cat. No. S1863	UNMOUNTED	$150.00 ppd.
	Cat. No. S1862	MOUNTED	175.00 ppd.

"BIG" ACHROMATIC TELESCOPE OBJECTIVES

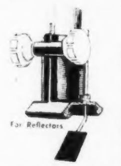
We have the largest selection of diameters and focal lengths in the United States available for immediate delivery. These are perfect magnesium-fluoride coated and cemented Gov't. surplus lenses made of finest crown and flint optical glass. Not mounted. Fully corrected. Tremendous resolving power.

● ALUMINUM TUBING and CELLS are in stock ●

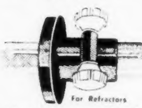
Cat. No.	Diam.	F.L.	ppd.	Cat. No.	Diam.	F.L.	ppd.	Cat. No.	Diam.	F.L.	ppd.
S1476	(2⅛")	(10")	$12.50	S1520	(2⅛")	(50")	$12.50	S-957	(3¼")	(40")	$30.00
S1112	(2⅛")	(11¾")	12.50	S-851	(3-1/16")	(15")	21.00	S1155	(4")	(34½")	60.00
S1110	(2⅛")	(13")	12.50	S1158	(3⅛")	(19½")	28.00	S1460	(4¼")	(36")	60.00
S-958	(2⅛")	(15½")	9.75	S-822	(3-3/16")	(24½")	22.50	S1159*	(4⅜")	(42")	60.00
S1145	(2⅛")	(20")	12.50	S1092	(3¼")	(26")	28.00	S1225	(4⅜")	(42")	67.50
S-952	(2⅛")	(23½")	12.50	S1093	(3¼")	(28")	28.00	S1474*	(5-1/16")	(24¾")	75.00
S1431	(2⅛")	(30")	12.50	S1139	(3¼")	(30")	28.00	S1475	(5-1/16")	(24¾")	85.00
S1432	(2⅛")	(40")	12.50	S-955	(3¼")	(34½")	28.00				

*Not coated.

Rack-&-Pinion Eyepiece Mounts



For Reflectors



For Refractors

Here is a wonderful opportunity for you to own a most mechanically perfect Rack-&-Pinion Focusing Eyepiece Mount with variable tension and adjustment. Will accommodate a standard 1¼" eyepiece, positive or negative. The body casting is made of lightweight aluminum with black-crackle paint finish, focusing tube of chrome-plated brass. Focusing tube for refractors has a travel of 4", for reflectors 2", and will fit all size tubing.

REFRACTOR TYPE

Cat. No. S1494 for 2⅞" I.D. Tubing .....$12.95 ppd.
Cat. No. S1495 for 3¼" I.D. Tubing ..... 12.95 ppd.
Cat. No. S1496 for 4⅜" I.D. Tubing ..... 12.95 ppd.

REFLECTOR TYPE

Cat. No. S1976 (less diagonal holder) ......$8.50 ppd.
Cat. No. S1982 DIAGONAL HOLDER .... 1.00 ppd.

● FREE CATALOG ●

Millions of lenses, prisms, eyepieces, rack-and-pinion eyepiece mounts, cells, aluminum tubing, mirrors, binoculars, telescopes, parts, accessories, and so forth. Write today!

We pay POSTAGE IN U. S. — C.O.D.'s you pay postage. Satisfaction guaranteed or money refunded in 30 days.

A. JAEGERS

6915 MERRICK RD., LYNBROOK, N. Y.

GLEANINGS FOR ATM's

CONDUCTED BY ROBERT E. COX

Measuring the Magnification of a Telescope

When a friend who is viewing the moon or a double star through your telescope asks what magnification you are using, can you give him a precise answer? Or if you are a lunar and planetary observer who makes drawings of what you see, can you label the magnification on each drawing with confidence that it is right?

Often there is a considerable difference in the rated and the actual power of a commercially produced telescope, and eyepieces very frequently fail to have their catalogue focal lengths. Manufacturers of mass-produced optics are not necessarily at fault in this, because cost prohibits individually measuring and marking each assembly. Although radii of curvature, lens thicknesses and spacing can each be kept within design tolerances, the accumulation of small differences may result in a sizable variation in the assembled eyepiece or telescope.

An amateur's own instrument must also be tested with various eyepieces to determine the effective magnifications. War-surplus elements and eyepieces have very roughly labeled powers, and specifications furnished with them are often unreliable. Finally, when a Barlow lens is used to increase the power, the setting of the Barlow in its adapter tube is usually done haphazardly and the actual magnification obtained is quite uncertain.

It is evident from the foregoing that one cannot simply take published specifications and apply them to the well-known relation that the magnifying power is the focal length of the objective lens or mirror divided by the focal length of the eyepiece. Fortunately, however, there is a simple method by which the magnifying power of a telescope can be measured, good accuracy being obtained without the use of elaborate accessories.

The method is based on a fundamental relation among three quantities: M, the magnification of any objective-ocular combination; D, the diameter or clear aperture of the objective or mirror; and R, the diameter of the objective's image formed behind the eyepiece. This formula,

$$M = D/R,$$

holds even for telescopes with erecting systems, Barlow lenses, or secondary mirrors, if they cause no vignetting.

Since the objective diameter is easily measured, our problem is to determine R. One procedure is to focus the telescope for infinity (perhaps on a star) and later point it to the daytime sky. Move a piece of ground glass or white card back and forth behind the eyepiece until the point is found where the emergent beam is smallest and most sharply defined. This circle of light is the *exit pupil* or *Ramsden disk;* its position is where an observer should place his eye to see the complete field of view of the instrument.

The Ramsden disk is generally quite small. For a 6-inch reflector of 50″ focus, it is only 0.120″ across with a 50x ocular, and 0.030″ at 200x. This is too small to measure by holding a ruler behind the eyepiece, even with the aid of a magnifying glass.

However, there are available today pocket-sized optical comparators that contain reticles graduated to read dimensions to the nearest 0.005″. These cost from $7.95 to over $25.00, and will give fairly good results for a 6-inch telescope at low powers. But for powers higher than about 200x, a measuring device that can be read to 0.001″ is desirable.

I have found very satisfactory an Edmund 50x pocket microscope with a scale 0.100″ long divided in units of 0.001″. The accuracy of this instrument was checked against a set of feeler gauges and found to be consistently good. In measuring the size of the Ramsden disk of a 6-inch telescope at 50x, one division corresponds to a difference of 1x, and at 200x to 6x.

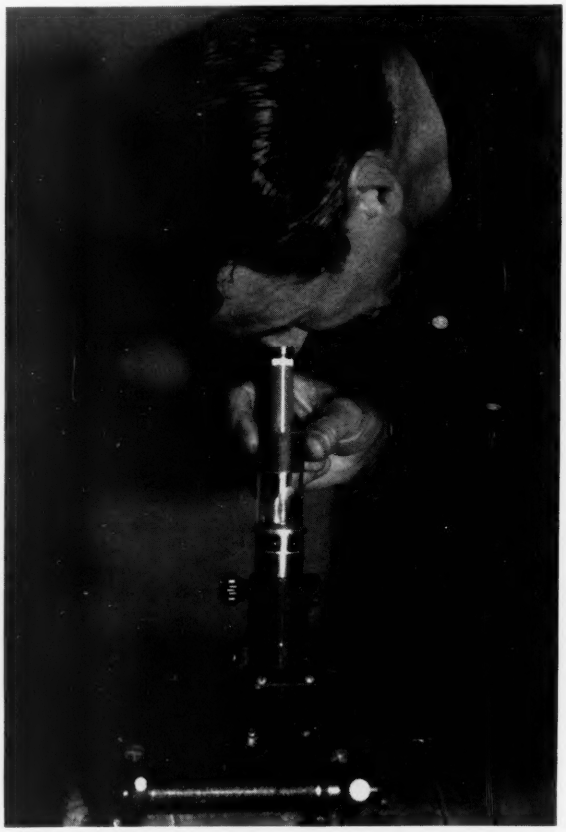
Having ascertained the magnification

of an objective-eyepiece combination (by measuring the Ramsden disk and using the formula), we next wish to know the individual focal lengths of the two. For the telescope objective or mirror, measurement of the focus is relatively easy; one simple way is to use the element as if it were a burning glass, and measure the distance from the lens or mirror to where the solar image is smallest. The equivalent focal length of the eyepiece (f) is computed from the relation, $f = F/M$, where F is the focal length of the objective or mirror.

As an example, suppose that with a 6-inch reflector the diameter of the Ramsden disk has been measured as 0.025". Then the magnification with this particular eyepiece is 6"/0.025" = 240. If we have measured the focal length of the mirror as 48", then the equivalent focal length of the ocular is 48"/240 = 0.20".

Measuring the Ramsden disk may be difficult, for one or two reasons. Irradiation can cause it to appear larger than it actually is, especially if the disk is too bright. Often, at low powers the disk will be larger than the 0.100" limit of the measuring reticle, but it can be brought within scale by reducing the telescope's aperture by a diaphragm of accurately known size.

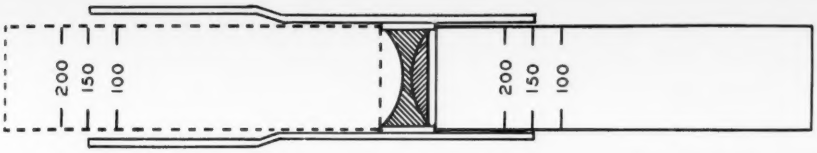
An alternative method that avoids several sources of error is to scribe with dividers a circle of appropriate size on a sheet of clear plastic 1/16" or 1/8" thick.



Earl Bess, telescope making instructor of the St. Louis Astronomical Society, here measures the size of the Ramsden disk of a 6-inch reflector and eyepiece combination. At the bottom of the picture the upper end of the telescope tube is seen, setting horizontal with the mirror end toward the right. A part of the finder is visible. Mr. Bess is looking through a microscope mounted in a wooden collar or bushing, the latter in turn being attached to a clear plastic cylinder, which acts as a spacer and holds the microscope in position for measuring the Ramsden disk size. Photograph by Robert E. Cox.

The circular scratch is then filled in with ink or black paint. When the sheet is held in front of the telescope, a corresponding black circle is seen in the Ramsden disk, and its diameter is measured instead of the whole disk. This procedure is recommended whenever magnification is determined with a reticle, as it avoids the disappearance of the graduations outside the image.

For accuracy, it is particularly important that the telescope be focused at infinity. This can be done indoors with the aid of a small collimator, which can be a finder whose reticle has been accurately positioned, following the instructions given on page 440 of the May issue. Preferably, the collimator lens should



If a Barlow lens is adjusted by pushing a blunt stick into one end of the adapter tube, the stick position shown by dashes may be used as a check.

have a diameter of at least 2" and a focal length of over 20".

In using the collimator, place the telescope with its tube horizontal. The collimator is put in front of the telescope, which is then focused until the illuminated reticle, as viewed through the telescope ocular, is as sharp as possible. This adjustment should be made by the same person who will be using the instrument in actual observing. Then, any imperfect accommodation of his eye will not affect the numerical value of the telescope's magnification when he is observing.

As already implied, a device for measuring the Ramsden disk should be particularly useful to observers who employ a Barlow lens to increase magnification. As ordinarily sold, the negative lens can be slid along its adapter tube, permitting amplification of up to two or three times. The magnification corresponding to any setting of the Barlow lens can be found from a measurement of the diameter of the Ramsden disk.

Instead, the amateur may want to know beforehand just what Barlow settings will give a selected set of powers, such as 100x, 150x, 200x, and so on. First the size of the Ramsden disk for the desired power is calculated, then the lens is shifted back and forth along its tube by inserting a broad piece of wood (not a finger), until this size is obtained. For consistent results, the ocular should always be firmly seated in the adapter tube, as any difference in placement affects the power.

Once the Barlow position is found for a particular magnification, the eyepiece is removed and a mark made on the wooden pusher to show the distance from the lens cell to the end of the adapter tube. Finally, each mark is labeled with the appropriate power. If several eyepieces are to be used with the same Barlow, a separate set of marks is needed for each, but these sets could be on different sides of a hexagonal or square stick, instead of on individual pieces of wood. The whole calibration process can be conveniently done indoors, with the aid of a collimator as described above. R. E. C.

A Portable Observatory for Small Telescopes

After a telescope, the most desirable possession for an amateur is a permanent observatory. However, to acquire one is usually costly. Moreover, if the owner decides to change his residence, moving the permanent installation becomes a major task.

Throughout seven or eight years of observing, I have had to battle the elements — wind, dew, cold — and man-made interferences, such as porch lights. For shelter, I have tried to improvise with tents, vinyl plastic coverings, even a table, but with little success.

Last November I came upon a material — Fomecor — which seemed ideal for a portable observatory. This is a $\frac{1}{4}$"-thick lightweight insulating material that is being tested for use in Antarctic regions. It has a plastic-foam core and is laminated on two sides with heavy Kraft paper.

I designed a scale model, 1/6 actual size, of the observatory and turned it over to a cardboard company in Chicago, Illinois. The first prototype was presented to the Chicago Astronomical Society last January.

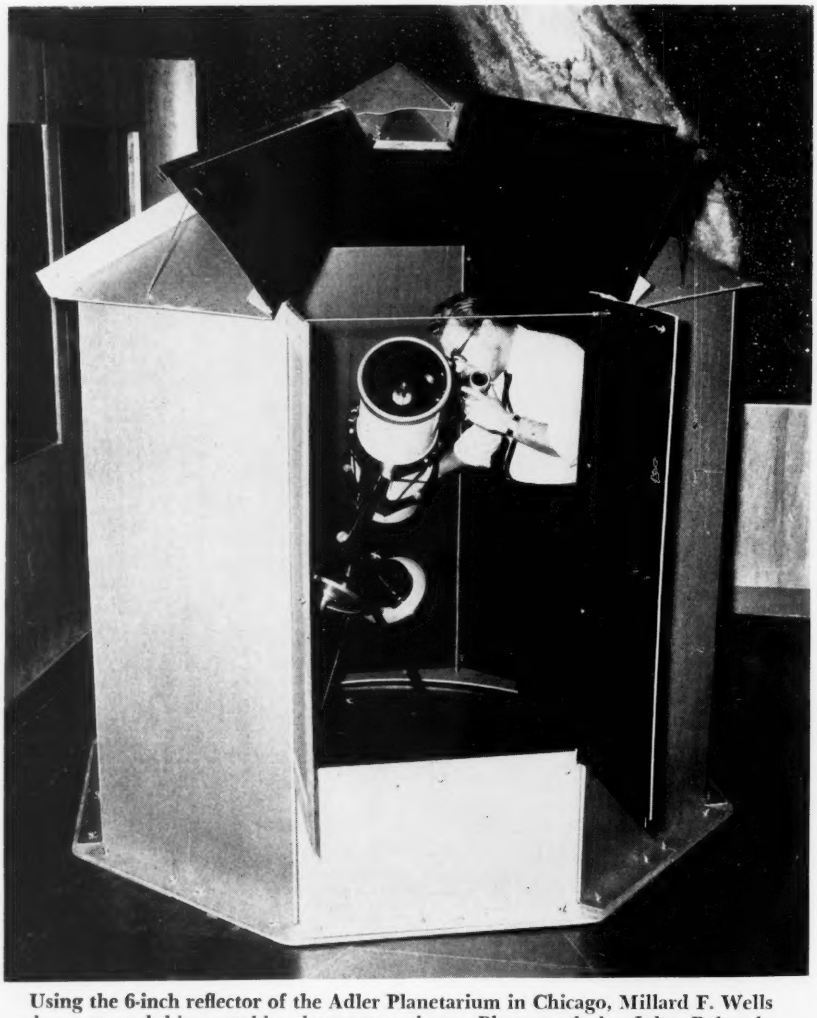
The observatory is 80" in diameter, $7\frac{1}{2}$' high, and weighs about 50 pounds assembled. It is made up of 17 sections, each having $\frac{1}{2}$" grommets bordering its edges. The pieces are fitted together with cadmium-plated bolts and wing nuts. The dome doors are held open with two cadmium-plated rods, which in turn fit into grommets located in the roof. Plywood strips give strength to the door.

Two persons can easily put the unit together in 20 minutes. For repacking, it fits into a telescoping box that measures 32" wide, 6' long, and 38" deep. This container easily goes into a station wagon.

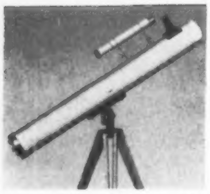
During an observing session, the housing can be moved or pushed on its base to any desired position. I can observe for about an hour without moving it. If there is a strong wind, there are six L-shaped hooks that can be driven into the ground along the plywood ring base.

The structure is finished in silver on the outside, flat black inside.

MILLARD F. WELLS
1033 Rice St.
Bellwood, Ill.



Using the 6-inch reflector of the Adler Planetarium in Chicago, Millard F. Wells demonstrated his portable observatory there. Photograph by John Babcock.



3-inch Astronomical Reflector

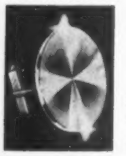
60 to 180 Power
An Unusual Buy!

Assembled — ready to use! See Saturn's rings, the planet Mars, huge craters on the moon, star clusters, moons of Jupiter, double stars, nebulae, and galaxies! Equatorial-type mounting with locks on both axes. Aluminized and over-coated 3"-diameter f/10 primary mirror, ventilated cell. Telescope comes equipped with a 60x eyepiece and a mounted Barlow lens, giving you 60 to 180 power. A finder telescope, always so essential, included. Sturdy, hardwood, portable tripod.

FREE with Scope: Valuable **STAR CHART** plus 272-page **"HANDBOOK OF THE HEAVENS"** plus the book **"HOW TO USE YOUR TELESCOPE."**

Stock #85,050-Y .... $29.95 ppd.

OFFSPRING OF SCIENCE . . . REALLY BEAUTIFUL!



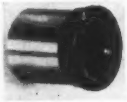
CIRCULAR DIFFRACTION-GRATING JEWELRY

A Dazzling Rainbow of Color!

Shimmering rainbows of gemlike color in jewelry of exquisite beauty — made with CIRCULAR DIFFRACTION-GRATING REPLICA. Just as a prism breaks up light into its full range of individual colors, so does the diffraction grating. Promises to become a rage in current fashion.

Stock #30,349-Y . . Earrings (clip style) ..... **$2.75 ppd.**
Stock #30,350-Y . . Cuff Links ..... **$2.75 ppd.**
Stock #30,372-Y . . Pendant ..... **$2.75 ppd.**
Stock #30,373-Y . . 2 pins ..... **$2.75 ppd.**
Stock #30,390-Y . . Tie Clasp ..... **$2.75 ppd.**
(All prices include tax.)

STANDARD 4-mm. ORTHOSCOPIC EYEPIECE



These are best for extremely high magnification (300 power with a 48"-f.l. objective). You get a wide, flat field — almost 3 times as much field as a Ramsden of the same power — excellent color correction and definition. Precision made of brass, chrome plated and black enameled. Inside is dead-black anodized with anti-glare shield.

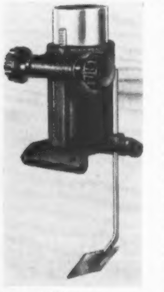
Stock #30,364-Y .... Only $14.50 ppd.

WAR-SURPLUS TELESCOPE EYEPIECE

Mounted Kellner eyepiece, type 3. Two achromats, focal length 28 mm., eye relief 22 mm. An extension added. O.D. 1¼", standard for most types of telescopes. Gov't. cost $26.50.

Stock #5223-Y .... $7.95 ppd.

Rack & Pinion Eyepiece Mounts

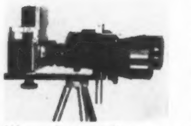


Real rack-and-pinion focusing with variable tension adjustment; tube accommodates standard 1¼" eyepieces and accessory equipment; lightweight aluminum body casting (not cast iron); focusing tube and rack of chrome-plated brass; body finished in black wrinkle paint. No. 50,077-Y is for reflecting telescopes, has focus travel of over 2", and is made to fit any diameter or type tubing by attaching through small holes in the base. Nos. 50,103-Y and 50,108-Y are for refractors and have focus travel of over 4". Will fit our 2⅞" I.D. and our 3⅞" I.D. aluminum tubes, respectively.

For Reflectors
Stock #50,077-Y . . (less diagonal holder) .... **$8.50 ppd.**
Stock #60,049-Y . . (diagonal holder only) .... **1.00 ppd.**

For Refractors
Stock #50,103-Y . . (for 2⅞" I.D. tubing) .... **12.95 ppd.**
Stock #50,108-Y . . (for 3⅞" I.D. tubing) .... **13.95 ppd.**

NEW BINOCULAR-TO-CAMERA HOLDER
For Exciting Telephoto Shots
Will fit any camera.



Bring distant objects 7 times nearer with a 35-mm. camera, 7 x 50 binocular, and our NEW BINOCULAR-TO-CAMERA HOLDER. Ideal for photographing the constellations, star clusters, the moon, as well as cloud formations, wildlife, vistas. Camera and binocular attach easily. Use any binocular or monocular — any camera, still or movie. Take color or black-and-white. Attractive gray crinkle and bright chrome finish, 10" long. Full directions for making telephotos included.

Stock #70,223-Y .... $11.50 ppd.

Take Pictures Through Your Telescope with the EDMUND CAMERA HOLDER for TELESCOPES

Bracket attaches permanently to your reflecting or refracting telescope. Removable rod with adjustable bracket holds your camera over scope's eyepiece and you're ready to take exciting pictures of the moon. You can also take terrestrial telephoto shots of distant objects. Opens up new fields of picture taking!

SUN PROJECTION SCREEN INCLUDED

White metal screen is easily attached to holder and placed behind eyepiece. Point scope at sun, move screen to focus . . . and you can see sunspots!

All for the low, low price of $9.95

Includes brackets, 28¾" rod, projection screen, screws, and directions. Aluminum . . . brackets black crinkle painted.

Stock #70,162-Y .... $9.95 ppd.

PRISM STAR DIAGONAL

For comfortable viewing of the stars near the zenith or high overhead with refracting telescopes using standard size (1¼" O.D.) eyepieces, or you can make an adapter for substandard refractors. Contains an excellent high-quality aluminized right-angle prism. The tubes are satin chrome-plated brass. Body is black wrinkle cast aluminum. Optical path of the system is about 3½".

Stock #70,077-Y .... $12.00 ppd.

AMICI-PRISM STAR DIAGONAL

Same as above except contains Amici roof prism instead of usual right-angle prism. Thus your image is correct as to top-bottom, making it excellent for terrestrial viewing.

Stock #50,247-Y .... $12.00 ppd.

ASTRO-COMPASS AND TRANSIT

War-surplus! Astro-Compass alone cost gov't. $75. We have added a sighting level to improve versatility. Hundreds of uses in carpentry, bricklaying, foundation work, grading, irrigation or drainage. Much below cost of ordinary surveying instruments. Ideal for do-it-yourselfers. 10¼" high, 6" long, 4" wide. Adjustable leveling platform — 2 spirit levels for aligning — also spirit level in sighting attachment. A tremendous bargain.

Stock #70,267-Y .... $19.95 ppd.

NOW! LENS ERECTOR FOR TERRESTRIAL VIEWING WITH YOUR REFLECTOR

This new Edmund development adds real convenience to viewing objects on the earth. Just put the lens erector in your eyepiece holder, insert eyepiece, and focus normally. You see everything right side up and correct as to left and right. Made of polished chrome-finish brass telescoping tubing that will fit any standard 1¼" eyepiece holder. Tubing is 9½" long and slides 3" into eyepiece holder. Erecting system consists of two coated achromats.

Stock #50,276-Y .... $9.95 ppd.

TELESCOPE ROLL-FILM CAMERA

This model uses rolls of #127 film. Picture area will be a circle 1-9/16" in diameter.

The advantage of this model is the ease of using roll film. With each camera you get a piece of ground glass. Before loading film in the camera, you focus the telescope. Then lock it in this position. For positions other than infinity, you can scribe a mark on your tube.

Stock #70,182-Y .... $29.50 ppd.

SHEET-FILM CAMERA

Uses sheet film 2¼" x 3¼" size. Camera box size is 3" x 4" x 5".

Stock #70,166-Y .... $39.50 ppd.

Ideal for Beginners . . .

STARMASTER ASTRONOMY SET!

Bring the thrills and wonders of outer space right into your home with this fascinating, educational Astronomy Set. De Luxe, 37-piece Set includes separate film projector and action pictures of a trip to the moon, from blast-off to return. Exciting views of the moon, planets, comets, distant galaxies, sun explosions, star clusters, other space wonders.

Also star projector and constellation projector (each approx. 4½" high). Projectors show many great constellations and stars, outline forms of Big Bear, Sagittarius, Southern Cross and others, for easy identification.

Also includes 10x telescope (single-element lens, meniscus, nonachromatic) with 1" aperture, suitable for viewing the moon.

Power source, flashlight pointer, and instructions included. Lower-priced Junior Set with single projector also available, but without telescope.

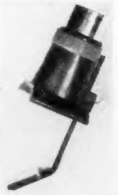
Stock #70,234-Y .... De Luxe .... **$10.00 ppd.**
Stock #70,233-Y .... Junior .... **$ 5.00 ppd.**

6X FINDER TELESCOPE

Has crosshairs for exact locating. You focus by sliding objective mount in and out. Base fits any diameter tube — an important advantage. Has 3 centering screws for aligning with main telescope. 20-mm.-diameter objective. Weighs less than ½ pound.

Stock #50,121-Y .... $8.00 ppd.

STANDARD 1¼" EYEPIECE HOLDER

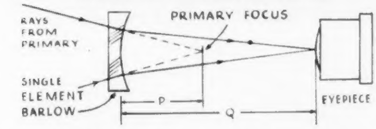


Here is an economical plastic slide-focus eyepiece holder for 1¼" O.D. eyepieces. Unit includes 3"-long chrome-plated tube into which your eyepiece fits for focusing. Diagonal holder in illustration is extra and is not included.

Stock #60,067-Y .... $2.50 ppd.

EDMUND SCIENTIFIC CO.

DOUBLE AND TRIPLE YOUR TELESCOPE'S POWER WITH A BARLOW LENS



WHAT IS A BARLOW? A Barlow lens is a negative lens used to increase the power of a telescope without resorting to short focal length eyepieces, and without the need for long, cumbersome telescope tubes. Referring to the diagram above, a Barlow is placed the distance P inside the primary focus of the mirror or objective. The Barlow diverges the beam to a distance Q. This focus is observed with the eyepiece in the usual manner. Thus, a Barlow may be mounted in the same tube that holds the eyepiece, making it very easy to achieve the extra power. The new power of the telescope is not, as you might suppose, due to the extra focal length given the objective by the difference between P and Q. It is defined as the original power of the telescope times the quotient of P divided into Q.

Beautiful chrome mount. We now have our Barlow lens mounted in chrome-plated brass tubing, with special spacer rings that enable you easily to vary the power by sliding split rings out one end and placing them in other end. Comes to you ready to use. Just slide our mounted lens into your 1¼" I.D. tubing, then slide your 1¼" O.D. eyepieces into our chrome-plated tubing. Barlow lens is nonachromatic.
Stock #30,200-Y...Mounted Barlow lens....**$8.00 ppd.**

UNMOUNTED 3X BARLOW LENS

These lenses are made for telescopes that have smaller diameter eyepieces than the standard 1¼" size. Mount one between the eyepiece and objective, and triple your power. Instructions included. Single-element lens, focal length −1-5/16", unmounted.
Stock #30,185-Y....0.932" diam...........**$3.50 ppd.**
Stock #30,328-Y....0.912" diam...........**$2.50 ppd.**

3X ADJUSTABLE-DIAMETER BARLOW LENS

For telescopes with eyepieces smaller than the standard 1¼" outer-diameter size. Prongs on mount can be opened or closed to fit tubes from 13/16" to 1" outer diameter. Directions for using included.
Stock #30,339-Y......**$5.00 ppd.**

MORE POWER FROM YOUR JAPANESE TELESCOPES

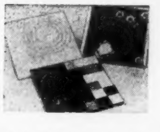
Mounted Barlow for Japanese Telescopes

By inserting this single-element lens in the eyepiece end of your Japanese telescope, and putting your regular eyepiece in the end of the Barlow tube, you can increase your telescope's power up to three times. Thus, instead of 60x, you will get 120x or 180x. Barlow is mounted in two pieces of telescoping brass tubing each 4" long, satin chrome plated on the outside. Inner diameter of large tube and outer diameter of small tube are 0.965", the standard size for most Japanese telescopes. Measure yours before ordering. 0.965" is approximately 31/32" or 24.5 mm.
Stock #30,370-Y.........................**$6.00 ppd.**

BARGAIN! MOUNTED ACHROMATIC BARLOW LENS

2-element, low-reflection-coated, negative achromat which will increase the power of your telescope over 3 times. The short focal length (−1.74") allows the lens to be used close to the primary focus, eliminating the need for long cumbersome tubes as in most long-focus Barlow systems. Outside diameter of tube, 1¼" (standard eyepiece size). Your standard eyepieces will fit in the other end. Spacers are included to vary the power. Complete directions.
Stock #30,374-Y........................**$15.00 ppd.**

SPACE RINGS THE FLOATING MOBILE



New Space Rings kit creates beautiful floating mobiles in endless variety — graphically demonstrates engineering concepts, math equations utilizing rectangular and polar co-ordinates. Kit consists of 4 perforated aluminum rings from 4" to 8" diameter, metallic elastic yarn in 7 shimmering colors, 1 large bronze-wire hoop, special ceiling hanger, and complete directions. Ideal creative hobby for older child or adult. Excellent teaching aid.
Stock #70,285-Y.........................**$4.95 ppd.**

EQUATORIAL MOUNT and TRIPOD with CLOCK DRIVE

Heavy-duty mount. Drive operates on 110-volt, 60-cycle, a.c. house current. Follows motion of stars smoothly. 32" tripod legs included.
Stock #85,081-Y....**$76.50** f.o.b. Barrington, N. J.

Same mount as above, without clock drive, for 8" or smaller reflectors and for 4" or smaller refractors.
Stock #85,023-Y.....New Low Price.....**$39.50** f.o.b. Barrington, N. J.

WAR-SURPLUS! AMERICAN-MADE!

7 x 50 BINOCULARS

Big savings! Brand new! Crystal-clear viewing — 7 power. Every optical element is coated. An excellent night glass — the size recommended for satellite viewing. Individual eye focus. Exit pupil 7 mm. Approx. field at 1,000 yds. is 376 ft. Carrying case included. American 7 x 50's normally cost $195. Our war-surplus price saves you real money.
Stock #1533-Y....................Only **$55.00 ppd.** (Tax included)

THE STARFINDER 12" CELESTIAL GLOBE

This beautiful new celestial globe brings the heavens before your eyes! The satellite-type mounting provides new ease in adjustment to place the stars on the globe in positions relating to the heavens at any given place and time.
Stock #70,279-Y..**$19.95 ppd.**

Mounted Ramsden Eyepieces

Standard 1¼" Diameter

Our economy model, standard-size (1¼" O.D.) eyepiece. We mounted two excellent quality plano-convex lenses in black anodized aluminum barrels instead of chrome-plated brass to save you money. The clear image you get with these will surprise you. Directions for using short focal length eyepieces are included with both the ¼" and ½" models.
Stock #30,204-Y.....¼" focal length.....**$4.75 ppd.**
Stock #30,203-Y.....½" focal length.....**$4.50 ppd.**

"MAKE-YOUR-OWN" 4¼" MIRROR KIT

The same fine mirror as used in our telescopes, polished and aluminized, lenses for eyepieces, and diagonal. No metal parts.
Stock #50,074-Y.........................**$16.25 ppd.**

STAR AND SPACE MAPS

Three giant maps: 1. THE SOLAR SYSTEM, 50" x 38", showing solar statistics; detailed moon map; 12 telephoto pictures of moon, sun, planets. 2. WORLD STAR CHART, 50" x 38"; locates stars for any time of year, any position on earth. 3. MAP OF THE SOLAR SYSTEM, 35" x 48"; shows planets, zodiac, and so on.
Stock #9245-Y....Set of 3 maps.........**$1.00 ppd.**

8" SETTING-CIRCLE SET

Stock #50,133-Y..Complete set .... **$3.00 ppd.**
Stock #60,078-Y..360° declination circle only **$1.60 ppd.**
Stock #60,079-Y..24-hour right-ascension circle only **$1.60 ppd.**

5¾" SETTING-CIRCLE SET

Stock #50,190-Y..Complete set........... **$2.50 ppd.**
Stock #60,080-Y..360° declination circle only **$1.35 ppd.**
Stock #60,081-Y..24 hour right-ascension circle only **$1.35 ppd.**

LARGE ERFLE EYEPIECE 1½" F.L.

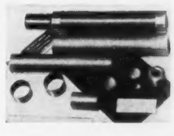
War-Surplus Bargain — Gov't. Cost Approx. $100

Large telescopes should have one of these for low-power viewing. Apparent field of view 65°. Also use with the 24"-focal-length Aerial Camera lens to make a 16-power wide-field telescope or a 27-power scope with one of the 40"-focal-length Aerial Camera lenses. Low-reflection-coated, 5-element lens system. Field lens of Eastman Kodak's rare-earth glass for better aberration correction. Has diopter scale. Smooth focusing ⅜" movement. Outside diameter of attaching threads, 3" — 32 threads per inch. Clear aperture of eye lens 2", field lens 1-25/32". Weight 3½ lbs.
Stock #50,091-Y..........................**$9.95 ppd.**

Attention! For Beginners, Junior Astronomy Clubs, Boy and Girl Scouts, Camp Groups, School Science Clubs

MAKE 8-POWER ASTRONOMICAL TELESCOPE

with Low-Cost Beginner's Kit!



Every boy and girl of today dreams of being a part of the exploration of outer space. That desire makes building his own telescope a real thrill. Now anyone of Cub Scout or Brownie age on up can make his own astronomical 8-power telescope in one evening, without tools or machinery. Here is an ideal, attractive group project for scouts, junior astronomy clubs, or similar groups. (See special quantity prices.) Scope is powerful enough to show craters of the moon, Jupiter's satellites, and many stars not visible to the naked eye. Kit includes objective lens, field lens, eye lens, glare stops, kraftboard tubes, cadmium-plated metal ferrules, and other parts to build an 18"-long, 1¾"-diameter telescope of 8 power.
Stock #70,238-Y..........................**$3.00 ppd.**

SPECIAL QUANTITY PRICES

Stock #70,239-Y.... 5 kits..............**$12.50 ppd.**
Stock #70,240-Y....10 kits..............**$22.50 ppd.**

BE SURE TO GET FREE CATALOG "Y"

128 Pages! Over 1000 Bargains!

Fantastic variety — rarely before have so many lenses, prisms, optical instruments, and components been offered from one source. Probably the greatest assembly of bargains in all America. Imported! War Surplus! Hundreds of other hard-to-get optical items. Many science and math learning and teaching aids.
Write for Free Catalog "Y".

EASY PAYMENT PLAN AVAILABLE! DETAILS WITH CATALOG

ORDER BY STOCK NUMBER . . . SEND CHECK OR MONEY ORDER . . . SATISFACTION GUARANTEED!

BARRINGTON • NEW JERSEY

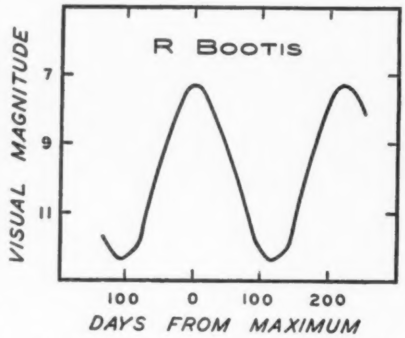
CELESTIAL CALENDAR

Universal time (UT) is used unless otherwise noted.

R BOOTIS

BOTH the Skalnate Pleso and Norton's star atlases indicate the position of the famous long-period variable star R Bootis, about $1\frac{1}{2}°$ west of the beautiful double, Epsilon Bootis. This variable is scheduled to reach maximum light (about magnitude 7.2) on August 1st, and should be within reach of binoculars or small finders during all of July and the following month.

The average period is 223.3 days, and at minimum the star fades to around 12.3. As with all other long-period variables, individual cycles can differ appreciably from the mean. Leon Campbell found that during the years 1921 to 1948 R Bootis' peak magnitudes ranged from 6.8 to 7.5, and that the intervals between successive maxima were as much as 233 or as little as 212 days.



A light curve by Leon Campbell, based on observations by the American Association of Variable Star Observers.

The variability of R Bootis was discovered at Bonn Observatory, in Germany, during wholesale measurements of star places for the famous catalogue and atlas of the northern heavens known as the *Bonner Durchmusterung*. E. Schönfeld had recorded it as magnitude $9\frac{1}{2}$ on March 6, 1856, but failed to detect it during check observations 25 days later. When F. W. Argelander surveyed this field with the Bonn meridian circle on May 7, 1858, he was surprised to find the star a little brighter than magnitude 9.0, and at once surmised variability. He confirmed this May 19th, when R Bootis had brightened to magnitude 8. During the century since, this orange-red star has been one of the best observed of all long-period variables.

ALDEBARAN AND THE MOON

WHEN the waning crescent moon rises about three hours before the sun on July 19th, it will be very close to Aldebaran in the sky. Watchers in the eastern part of the United States will see this orange 1st-magnitude star disappear at the moon's bright edge, near the northern tip of the crescent, and afterward reappear at the dark limb.

At Washington, D. C., Aldebaran will be occulted from 4:38 to 5:26 a.m. Eastern daylight time, the emergence of the star being only 30 minutes ahead of sunrise. The occultation will be more nearly central and last correspondingly longer in the southeastern states, while farther north and west it becomes nearly grazing. In western Illinois, for example, the star will be hidden only from 3:50 to 4:11 a.m. Central daylight time, very near the moon's northern edge.

Farther west, the moon is lower in the east at the time of the occultation. In central Texas, the event will begin before moonrise; Aldebaran will not be seen there until the moon passes from in front of it, at 4:10 a.m. Central daylight time.

On the West Coast, there will be no occultation after moonrise, but Aldebaran will be close above the moon, the two forming a beautiful pair before twilight begins, for both visual and photographic observations.

For detailed predictions of the July 19th occultation, consult the December, 1959, issue, pages 99 to 106.

MINOR PLANET PREDICTIONS

Vesta, 4, comes to opposition on July 2nd, and will be 6th magnitude at that time. It is now in Sagittarius, and should be easy to find with binoculars, using the chart on page 447 of the May issue.

Ceres, 1, 7.4. July 5, 22:20.6 −22-55; 15, 22:18.1 −23-59; 25, 22:13.1 −25-09. August 4, 22:06.2 −26-20; 14, 21:58.0 −27-25; 24, 21:49.2 −28-17. September 3, 21:40.9 −28-52; 13, 21:34.0 −29-08; 23, 21:29.1 −29-06. Opposition on August 19th.

Massalia, 20, 10.2. July 15, 21:35.7 −13-14; 25, 21:28.4 −13-49. August 4, 21:19.5 −14-31; 14, 21:09.9 −15-15; 24, 21:00.7 −15-57. September 3, 20:52.9 −16-32. Opposition on August 8th.

After the asteroid's name are its number and the approximate visual magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1950.0) for 0^h Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

JULY METEORS

The peak of the Delta Aquarid shower comes on July 29th this year, but some of these meteors can be seen up to 10 days earlier or later. Since the moon will then be two days after first quarter, it will not interfere with morning observations. Shortly before dawn, a single observer may count as many as 20 meteors per hour, if sky conditions are good. At the time of maximum, the radiant is located just west of Delta Aquarii, and is moving about a degree eastward each day.

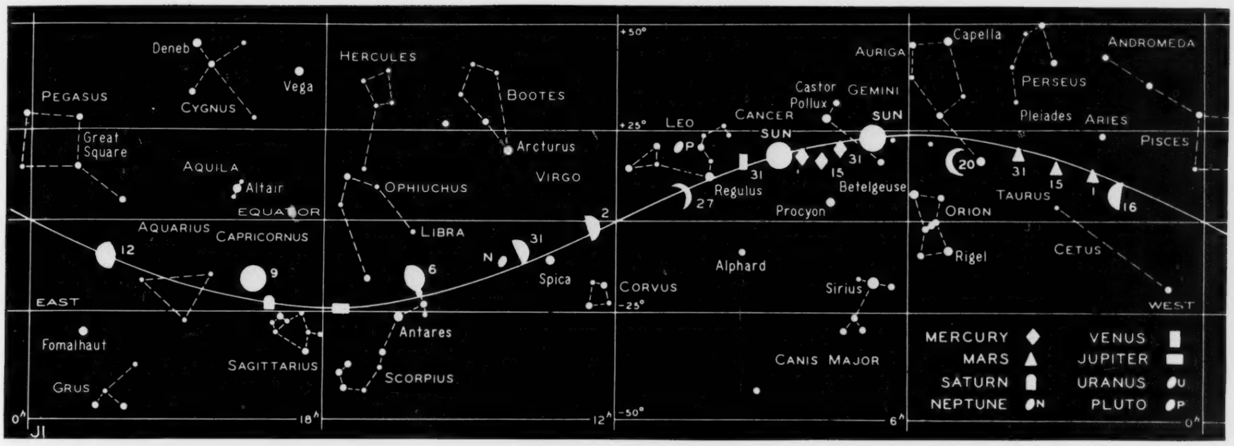
W. H. G.

MINIMA OF ALGOL

July 1, 10:44; 4, 7:32; 7, 4:21; 10, 1:10; 12, 21:58; 15, 18:47; 18, 15:36; 21, 12:24; 24, 9:13; 27, 6:01; 30, 2:50.

August 1, 23:28; 4, 20:27; 7, 17:16.

These minima predictions for Algol are based on the formula in the 1953 *International Supplement* of the Krakow Observatory. The times given are geocentric; they can be compared directly with observed times of the star's least brightness.



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other dates shown. All positions are for 0^h Universal time on the respective dates.

Mercury passes through inferior conjunction with the sun on July 17th. The solar glare will hide the planet until the end of the month, when Mercury may be glimpsed low in the east before sunrise. On the 31st it will rise about $1\frac{1}{4}$ hours ahead of the sun.

Venus is in the evening sky this month, but too near the sun to be well seen.

Mars rises just after midnight, local time, in mid-July, and can be observed in the early morning hours. It is in Aries, and of magnitude +0.9. The disk, however, is still quite small, 6″.3 in apparent diameter on the 15th. The moon will pass 3° south of Mars on the 17th.

Jupiter crosses the meridian about $2\frac{1}{2}$ hours after sunset in midmonth, and is a brilliant object of magnitude −2.1 near the Ophiuchus-Sagittarius border. It can be seen low in the southwestern sky until early morning. In a telescope the planet's flattened disk is 45″.6 in equatorial diameter, 42″.6 in polar. The chart at the right shows positions of the four bright satellites, which are readily observed in small instruments. The moon will pass 5° north of Jupiter on the morning of July 7th.

Saturn comes to opposition on July 7th, 839 million miles from the earth. It then rises about sunset and is visible in the southern sky all night. At this time the disk's polar diameter will be 16″.5, and the rings 41″.5 across. The moon will pass 4° north of Saturn at midday on July 8th. Saturn's brightest satellite, 8th-magnitude Titan, will be 3′ west of Saturn on July 1st and 17th, and 3′ east on the 9th and 25th. Its 16-day orbital motion is interesting to follow in small telescopes.

Uranus is an evening object in Leo, but the sun will interfere with viewing this 6th-magnitude planet.

Neptune reaches eastern quadrature on the 29th, and is past the meridian at sunset. Now moving very slowly near the Libra-Virgo border, on June 15th this 8th-magnitude planet is at right ascension 14^h $18^m.0$, declination −11° 56′ (1950 coordinates). A fair-sized telescope is needed to show its small disk.

W. H. G.

UNIVERSAL TIME (UT)

TIMES used in Celestial Calendar are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. To obtain daylight saving time subtract 4, 5, 6, or 7 hours, respectively. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown. For example, 6:15 UT on the 15th of the month corresponds to 1:15 a.m. EST on the 15th, and to 10:15 p.m. PST on the 14th.

VARIABLE STAR MAXIMA

July 2, RR Sagittarii, 194929, 6.8; 9, SS Virginis, 122001, 6.8; 15, Omicron Ceti, 021403, 3.4; 16, R Pegasi, 230110, 7.8; 24, X Ophiuchi, 183308, 6.8; 26, R Caeli, 043738, 7.9; 31, RU Herculis, 160625, 8.0.

August 1, R Bootis, 143227, 7.2; 6, R Draconis, 163266, 7.6; 8, R Normae, 152849, 7.2.

These predictions of variable star maxima are by the AAVSO. Only stars are included brighter than magnitude 8.0 at an average maximum. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for their maxima. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted visual magnitude.

MOON PHASES AND DISTANCE

First quarter	July 2, 3:49
Full moon	July 8, 19:37
Last quarter	July 15, 15:43
New moon	July 23, 18:31
First quarter	July 31, 12:39
Full moon	August 7, 2:41

July	Distance	Diameter
Perigee 8, 11^h	221,900 mi.	33′ 27″
Apogee 21, 14^h	252,500 mi.	29′ 24″
August		
Perigee 5, 20^h	223,500 mi.	33′ 13″

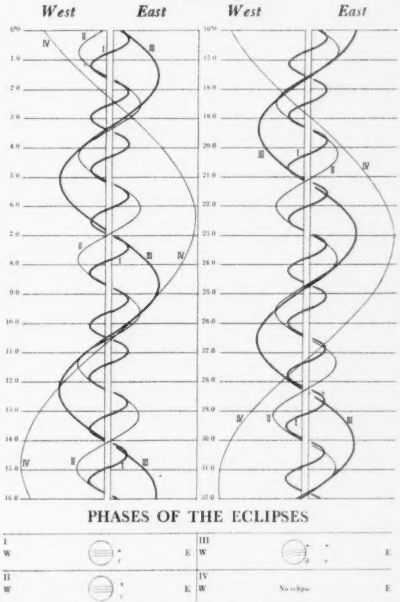
JUPITER'S SATELLITES

The curves in the accompanying chart show the positions of Jupiter's four bright moons, as seen in an inverting telescope, with north at the bottom and east at the right. Each horizontal line is for 0^h Universal time on the date specified, and the intersections of the line with the curves indicate the places of the satellites at that time. For other Universal times, interpolate between the 0^h lines. The double vertical lines represent the planet's disk.

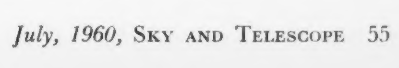
The lower section is intended to aid observations of the eclipses of Jupiter's moons; *d* is the point of disappearance of the satellite in Jupiter's shadow, *r* is the point of reappearance. The chart is from *The American Ephemeris and Nautical Almanac;* for further explanation, see page 446 of SKY AND TELESCOPE for May, 1960.

JUPITER'S SATELLITES IN JULY

UNIVERSAL TIME

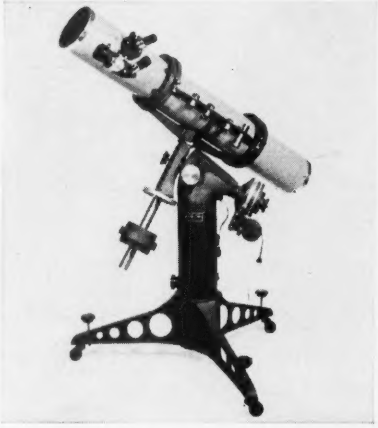


PHASES OF THE ECLIPSES



THE ★ ★ TRECKERSCOPE GALAXY ★ ★ SERIES

Now, as in the past, Coast Instrument's high quality is the standard of comparison! The American telescope company that provides 1/20th-wave optics for amateurs and professionals alike again is way out in front with the GALAXY. No other telescope manufacturer today offers as many outstanding features. These superb instruments are guaranteed to resolve to, or surpass, Dawes' limit on nights of good seeing. The GALAXY optics are hand-figured and, therefore, our instruments are able to produce results far better than expectations. All of the GALAXY telescopes include these outstanding features — rock-steady equatorial mount; quickly detachable legs for easy portability (only 70 seconds to assemble or disassemble entire scope for field trips); hydro-smooth rotating tube with built-in ocular rack; remote-assistance light; Opti-Set finderscope (only requires 3" movement of head from finder to eyepiece, which is directly in line); Hydro-Glide (ultrasmooth, no backlash) focusing device; fiberglass tube; your choice of any three of the finest-quality oculars (Ortho Stars), 7 mm. — 10 mm. — 16 mm. — 20 mm. — 27 mm., or any two oculars and a Coast Achromatic Barlow Lens; synchro-smooth clock drive with manual flex-line control for precise tracking when no 110-volt power is available; wheels for ease in moving from location to storage area (wheels snap out for viewing). Leveling screws are provided for any minor difference in ground level. All in all — your dollar cannot purchase better viewing. All of our instruments are American made, and you are protected by our 20-year unconditional guarantee.



GALAXY 6 INCH

THE DIFFERENCE BETWEEN THE BEST AND THE OTHERS IS SMALL

GALAXY 6" —$ 775.00
GALAXY 8" —$ 895.00
GALAXY 10" —$1295.00
GALAXY 12.5"—$1495.00

OUR EXTENDED PAYMENT PLAN IS OFFERED TO ALL TAKE MONTHS TO PAY 6 — 12 — 18 — 24 IF DESIRED . . .

WRITE FOR OUR LAB SPECIFICATION SHEET.

MIRRORS, PARABOLIC, GUARANTEED UP TO 1/20TH WAVE OR BETTER FROM COAST'S OWN OPTICAL SHOP, ALUMINIZED AND QUARTZ OVERCOATED

	6" f/10	6" f/8	8" f/7.5 or f/6	10" f/7.5 or f/6	12½" f/7.5 or f/6
1/20th WAVE		$82.50	$115.00	$255.00	$362.50
1/10th WAVE		$62.50	$95.00	$195.00	$282.50
1/8th WAVE	$47.50				
REFIGURING, NO CHANGE IN YOUR OWN FOCAL LENGTH					
1/20th WAVE		$47.50	$65.00	$110.00	$175.00
1/10th WAVE		$37.50	$55.00	$80.00	$125.00

ALL PRICES ABOVE INCLUDE MATCHING ELLIPTICAL DIAGONALS AND ALUMINIZING WITH QUARTZ OVERCOATING.

TREAT YOURSELF TO THE FINEST — Words alone cannot express the superb quality of COAST mirrors — they will positively amaze you with their "out-of-this-world" resolving power. This we guarantee you! Dawes' limit so easily!

TELESCOPE OPERATING MANUAL
by Raymond Dudley

Explains amateur telescope operation, including setting circles, sidereal time, alignment, orientation. Shows how to find 52 most beautiful objects in sky as well as general "how-to-observe" instructions. 44 pages of information every amateur needs.

$1.00 postpaid

HELAJUST FOCUSING MOUNT

Now at a new low price, but unexcelled in construction. Both push-pull for coarse adjustment, and helical movement for fine, precise focusing. Beautifully finished in black crackle and satin chrome, with a total extension of main tube and drawtube of 6", and engineered to fit all sizes of tubes without modification. Has single-vane-spider holding boss for those desiring this method of using diagonal. Guaranteed far superior to any other low-priced focusing mount, or **money back**. (Takes 1¼" eyepieces.) **$9.95**

ORTHO-STAR OCULARS

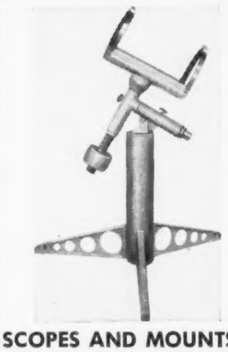
DUST SEALED — ALL COATED BEAUTIFUL FINISH

Guaranteed to be the finest you ever used—or return for full refund! Outstanding features: wide flat field, sharp to the very edge; extra-long eye relief; parfocalized for easy change of power; sealed-in optics, never need interior cleaning; hard coated, magnesium fluoride; boldly marked for easy identification; striking chrome and black-velvet finish, beautifully machined, 1¼" O.D.

ORTHO-STAR oculars are available in the following focal lengths, giving, for example, the indicated powers when used in conjunction with an 8" f/8 mirror: 27 mm.—61x; 20 mm.—81x; 16 mm.—102x; 10 mm.—163x; 7 mm.—233x.

$19.50 each ppd.

NOW AVAILABLE: 20-MM. ERFLE ORTHO-STAR OCULAR, 66°.7 apparent field. **$29.50 each ppd.**



TRECKER-PATHFINDER $89.50

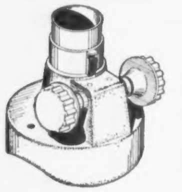
EQUATORIAL MOUNT — **complete**

This mount will accommodate 4-inch to 8-inch telescopes. Specify your tube size when ordering.

Standard 36-inch height — massive 1½-inch steel shafting, in oil-impregnated bronze bearings.

This amazing EQUATORIAL MOUNT is just what the doctor ordered for mounting that homemade telescope you labored so hard to finish. Now you can purchase a beautifully constructed, highly rigid equatorial mount, COMPLETE, for your own telescope as economically as if you had built it yourself. This terrific mount is made entirely of metal; all of the moving equatorial parts are polished to work with maximum ease. Legs, head, and counterweight are all removable for easy storing. The saddle allows complete rotation of your tube. One of the more important features in this mount is that the polar axle is extended for ease in attaching a clock drive and/or setting circles, which may be added at any time. The TRECKER-PATHFINDER mount also has a beautiful, chip-resistant finish. Taking all of these unusual features into consideration, this is truly one of the best DOLLAR-FOR-DOLLAR values.

USE OUR EXTENDED PAYMENT PLAN ON ALL SCOPES AND MOUNTS



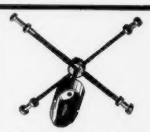
HYDRO-GLIDE Precision Focusing Device

Coast Instrument's own "Hydro-Glide" (type formerly referred to as "rack and pinion"). Now you can have WHISPER-SMOOTH control with absolutely no high and low spots as geared units have. This has never before been available in **any** focusing mount. Standard in appearance, yet utilizing an entirely **new** concept. We guarantee you will be astonished at its unbelievable superiority. If this isn't the absolute "smoothest," **return it for full refund.** **$18.50 patent pending**

MIRROR CELLS

Skeleton type

6" ...... **$6.95** 10" **$17.95**
8" ...... **$10.95** 12½" ... **$21.00**

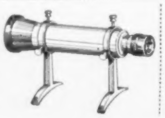


4-VANE SPIDERS

6" ...... **$11.50** 10" **$14.95**
8" ...... **$11.50** 12½" ... **$16.95**

TRECKER FINDER

7x, 50-mm. objective, helical focusing, with mounts and crosshairs. Same as used on TRECKERSCOPES. **$18.50**



Send for Coast Instrument's Professional MIRROR CLEANING KIT. **$2.35 ppd.**

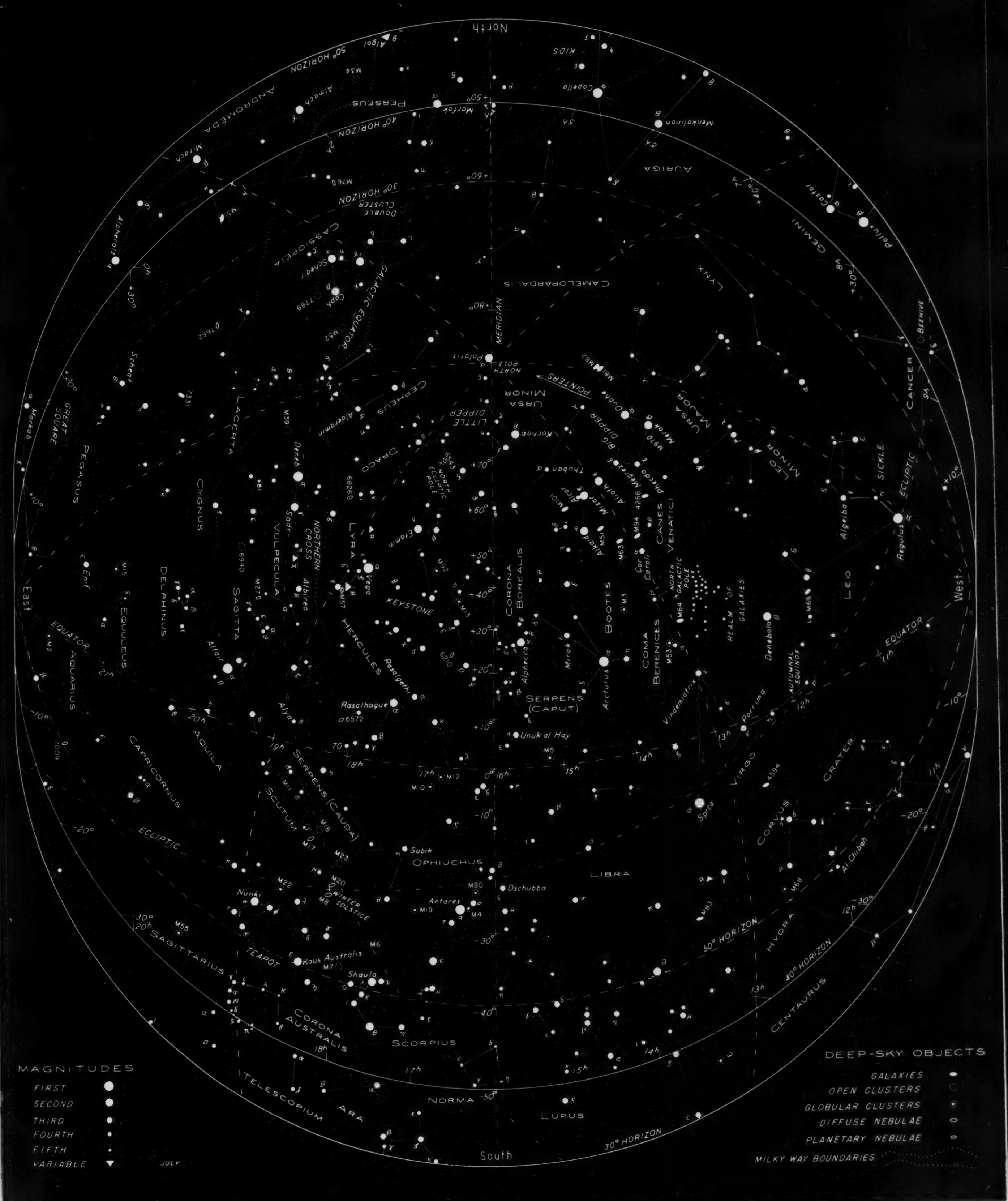
SEND FOR OUR NEW 68-PAGE CATALOG showing many of the other telescope items manufactured or distributed by COAST INSTRUMENT. It includes our treatise, "WHAT YOU SHOULD KNOW, LOOK FOR, AND DEMAND, BEFORE BUYING **ANY** TELESCOPE," an impartial, informative article that will give you information you've probably been looking for to help make up your mind as to just what telescope you should buy!

All prices, unless otherwise indicated, are at our warehouse in Long Beach, California, from where shipping charges will be added, and are subject to change without notice. Nominal crating charge added for all telescopes and mounts. California residents: Add 4% sales tax to all prices. NOW APPOINTING DEALERSHIPS . . . INQUIRIES INVITED.

TRECKERSCOPES ARE CUSTOM MADE IN AMERICA BY PROFESSIONAL OPTICIANS AND ENGINEERS.

COAST INSTRUMENT, INC.
"IN OPTICS SINCE 1933"

4811 Long Beach Blvd., Long Beach 5, Calif.
Phone: GArfield 2-3411 or NEvada 6-7683

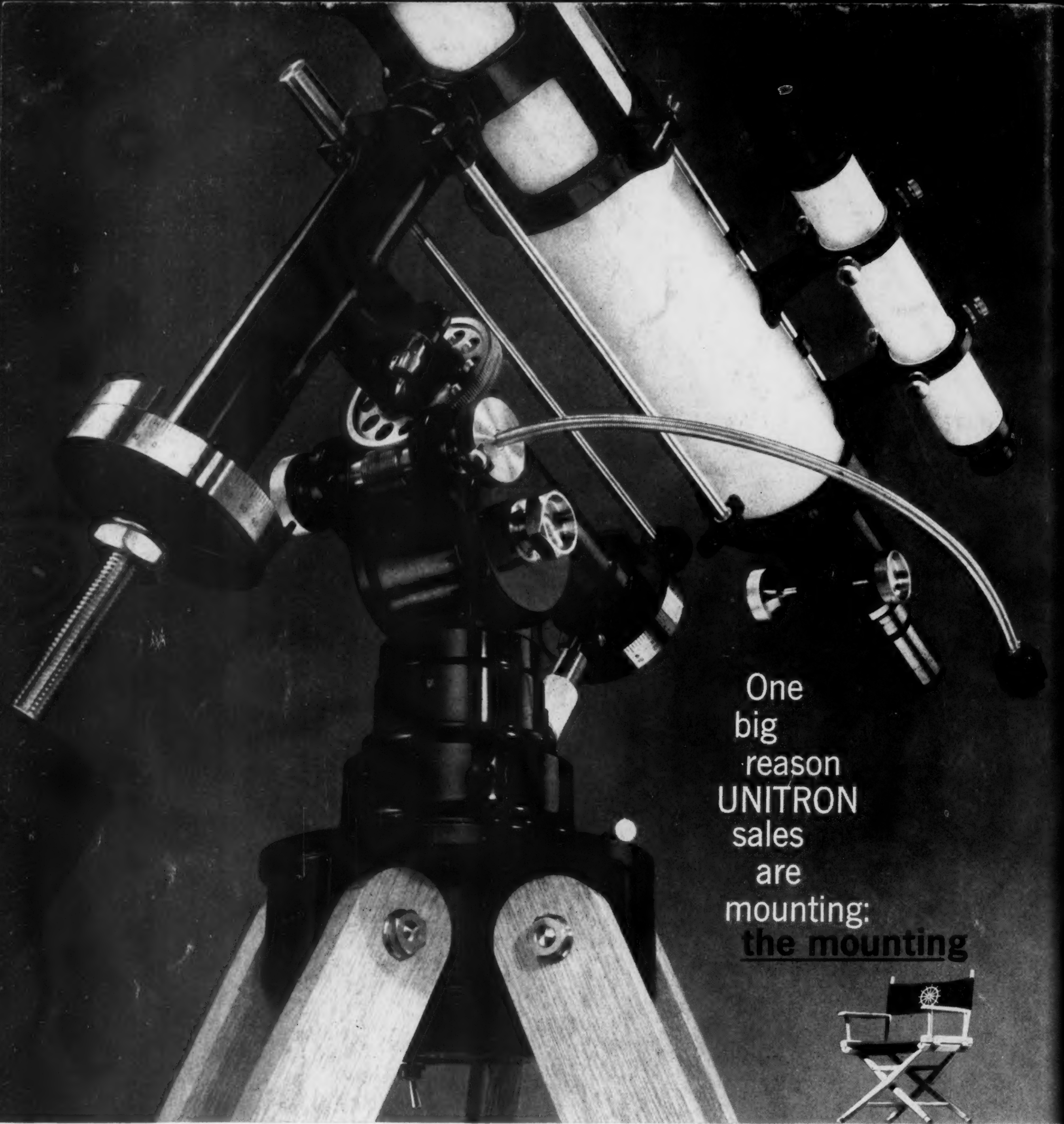


STARS FOR JULY

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 22nd of July, respectively; also, at 7 p.m. on August 6th. For other dates, add or subtract ½ hour per week.

In the eastern sky can now be seen the large summer triangle, formed by the 1st-magnitude stars Vega, Deneb, and Altair. Hercules and Bootes are nearly overhead, with beautiful Corona Borealis between them. The planet Jupiter is prominent east of Antares.

PRINTED BY WELLESLEY PRESS, INC.



Equatorial mounting of the 4″ UNITRON refractor, Model 152.

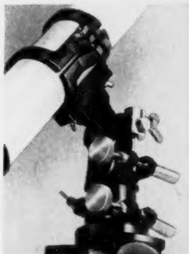
Step up, friend. Sit yourself down at the controls of a UNITRON. Feel the sure response of the slow-motion controls. Note the extra-smooth handling ease. Observe the oversize components, which give UNITRON mountings strength to spare.

If it's an altazimuth model, you have micrometric adjustments for both altitude and azimuth. In the equatorial models, you'll find the mechanism more sophisticated — but the operation is even easier. Here, once you've pinpointed your target, only the single right-ascension control is needed to keep the object centered in the field of view. You'll welcome the added convenience of the new flexible cable extension which brings the right-ascension control within easy reach — a new feature included with all UNITRON equatorials as standard equipment.

Note, too, the precise slow-motion adjustment for declination. Scrutinize the precision gears designed to deliver generations of velvet-smooth performance. Examine the large easy-reading setting circles and verniers provided on the 3″ and larger models.

(What you won't see is the instrument's complex of inner workings — a blend of the arts of the artillery engineer and the Swiss watchmaker that gives you an instrument whose response will be obedient to the slightest touch of your fingers.)

And — while you're at it — don't forget to look through the refractor. UNITRON's optical excellence is the other big reason UNITRON sales are mounting.



Sturdy altazimuth mounting with slow-motion controls as well as rapid motions for altitude and azimuth.

UNITRON INSTRUMENT DIVISION OF UNITED SCIENTIFIC CO. — 204-206 MILK STREET, BOSTON 9, MASS.

SEE PAGES 44 AND 45 FOR MORE ABOUT UNITRON.

nting
ls as
s for

MASS.